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The genus Microascus

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THE GENUS MICROASCUS

by

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INTRODUCTION

The genus Microascus was established by Zukal (40) with M. longirostris as the type species. In its gross morphology, the ascocarp of M. longirostris is perithecial-like, being dark, carbonaceous, and long-necked; the asci, however, are distributed at all levels within the centrum as in the genus Eurotium. Realizing the Plectomycetous nature of the genus, Fischer (12) placed it in the Plectascineae in Engler and Prantl. This is noteworthy as one of the earlier records of centrum organization taking precedence over gross morphology as a taxonomic criterion. Microascus was later placed in the Sphaeriales by Curzi (7) but there is little evidence to support him in this treatment and it is not generally followed.

Since Zukal's publication, a number of Microascus-like fungi have been described under a variety of generic names. The affinities of many of these species to Microascus were realized by Emmons and Dodge (11), and by Curzi (7) who transferred them to the latter genus. There is some disagreement with respect to these transfers and the controversies concerning them will be discussed in some detail in the taxonomic section below. Curzi (6) also separated out a second series of Microascus-like species into a new genus Petriella. This separation was based largely on the setose condition of the perithecium in the latter genus. Petriella

has to date been regarded as quite distinct from Microascus.

Apart from the taxonomic problems, Microascus is of special interest because of the many areas of activity with which its species are connected. Some have shown pathogenic tendencies against man, animals, plants, and even insects; others have been isolated frequently as coprophilous fungi and more recently as component organisms of the soil microflora. The relationship of Microascus in these associations is, for the most part, little understood.

The present study is a morphologic and taxonomic treatment of the genus Microascus, with special emphasis on its relationships to Petriella.

MATERIALS AND METHODS

A list of the fungi examined in the present study, and the sources from which they were obtained, is included in Table 1. In all cases, with the exceptions of *M. variabilis* (type herbarium material) and *M. lunasporus* (type slides) from the Cryptogamic Herbarium of the New York Botanic Gardens, living cultures were studied.

Initially the cultures were grown on a variety of media including Difco corn meal agar, Difco potato dextrose agar, Cyapek's synthetic medium with 20% and 3% sucrose, potato dextrose agar (P.D.A.), and corn meal agar (C.M.A.). The latter two media proved to be most suitable and were used consistently throughout the studies. The dextrose concentration of the P.D.A. was observed to have a considerable effect on colony habit and .6% dextrose was the concentration used.

The ascospores of a number of species of *Microascus* were found to be very similar in size and shape; for comparative purposes, therefore, all photographs of ascospores were enlarged to the same degree.

Table 1. Sources of cultures and herbarium specimens of *Microascus* species studied; not necessarily listed under the name as received

Source	Species	Culture number
American Type Culture Collection, 2029 M Street, Washington D.C.	*M. trigonosporus*	10131
Barnett, H. L., West Virginia University, Morgantown, West Virginia	*M. guttulatus*	1024
	M. setifer	924-a8
Benjamin, C. R., Agricultural Research Service, U. S. Dept. of Agriculture, Peoria, Illinois	*M. doguetii*	1715
	M. intermedius	A6900
	"	A6902
	"	A6912
	"	A6914
	"	A6915
	"	A6916
	M. lunasporus	2019
	M. nidicola	A6894
	"	A6895
	"	A6913
	M. trigonosporus	A6901
	"	1570
	M. variabilis	1717
Cain, R. F., University of Toronto, Toronto, Canada	*M. cinereus*	33033
	"	33044
	"	33045
	"	33046
	"	33062
	M. cirrosus	33047
	M. trigonosporus	33050
	"	33450
	M. guttulatus	31516
	"	33015
	"	33048
	"	33049
	M. sordidus	33032
	"	33041
	"	33042
	"	33063

Table 1. (Continued)

Source	Species	Culture number
Centraalbureau voor Schimmelcultures (C.B.S.), Baarn, Holland	M. albo-nigrescens	-
	M. cirrosus	-
	M. desmosporus	-
	M. manginii	-
	M. niger	-
	M. sordidus	-
	M. variabilis	-
Doguet, G., Université de Caen, Caen, France	M. doguetii	-
Durrell, L. W., State University, Fort Collins, Colorado	M. sordidus	-
Fuentes, C., University of Havana, Havana, Cuba	M. cinereus	-
Guillemat, J., École Nationale de Agriculture, Grignon, France	M. cirrosus	AS75
Iowa State College, Ames, Iowa	M. cinereus	501
	"	502
	"	503
	"	504
	"	505
	"	506
	"	507
	M. cirrosus	511
	M. intermedius	521
	"	522
	"	523
	M. schumacheri	531
	"	532
	"	533
	M. variabilis	541
	"	542
	"	543
	"	544
	"	545
	"	546
	"	547

Table 1. (Continued)

Source	Species	Culture number
Laboratoire de Cryptogamie, Rue de Buffon, Paris, France	M. stysanophorus	150
	"	506
	M. cirrosus	T7
New York Botanic Gardens, Cryptogamic Herbarium, New York	M. lunasporus	-
	M. variabilis	-
Orr, G. F., University of California, Los Angeles, California	M. cirrosus	1
	"	6
	M. trigonosporus	2
	M. trigonosporus var. macrosporus	3
	M. manginii	7
	Microascus sp.	4
	"	8
	"	9
	"	12
Rogerson, C., Kansas State College, Manhattan, Kansas	M. cinereus	0-44-4
	"	0-52-1
	"	0-110-2
	M. cirrosus	0-94-4
	"	4821A
	M. trigonosporus	4775A
Routien, Charles Pfizer & Co., Inc., Brooklyn, New York	M. trigonosporus	16M928
Smith, G., London School of Hygiene and Tropical Medicine, London	M. trigonosporus	BB22A
	M. manginii	-

MORPHOLOGY AND DEVELOPMENT OF THE ASCOCARP

Critical cytological investigations on several species of the genus have been carried out by Emmons and Dodge (11), Jones (20), Moreau (27), and Doguet (9). The results of these studies are outlined below.

The ascocarp is initiated by a favored vegetative cell giving rise to an ascogonial branch which is frequently coiled. The cells of the ascogonium are at first uninucleate but later become multinucleate. In M. lunasporus (sensu Jones), it was observed that antheridia are normally present and Jones (20) noted the passage of the antheridial nucleus into the ascogonium with subsequent pairing of the nuclei. Antheridia were not found by Moreau (27) in M. doguetii but in M. trigonosporus, Emmons and Dodge (11) noted that antheridial-like branches are sometimes present.

The ascogonium is septate with multinucleate cells and becomes enveloped rapidly by sterile vegetative hyphae giving the young ascocarp a globular shape. With further development the ascogonium becomes surrounded by several layers of pseudo-parenchymatous cells elongated in a tangential direction. The outermost cells become carbonized and pigmented while the inner layers remain thin-walled and hyaline. The perithecia enlarge and the innermost, hyaline, thin-walled cells round the ascogonium grow into the cavity formed by this enlargement. The cells, at first tapering, become

distinctly hyphal forming a myceloid matrix in the center of the ascocarp. These hyphae develop more rapidly below than above resulting in a differential growth which causes the ascogonium to take up a position above the center of the perithecium. Concurrent with this series of developments is the initiation of the ostiolar and neck regions; elongation of the outer layers to form a papilla or neck results in the formation of a shizogenous sub-ostiolar cavity which extends up to the ostiole and is accompanied by the inward growth of periphyses to form a lining round the ostiolar channel.

The ascogenous hyphae grow out radially from the ascogonium, particularly in a downard direction, into the body of the centrum. The ascogenous hyphae branch freely and by mutual pressure become radially arranged. Croziers are never found consistently but have been observed infrequently by Emmons and Dodge in M. trigonosporus. Asci arise variously from the ascogenous hyphae; either singly or in tufts from the terminal and lateral branches or sometimes intercalary and in rows as found by Moreau in M. doguetii.

The asci are produced first in the region around the ascogonium and further development follows the maturation of the ascogenous hyphae towards the periphery of the ascocarp. The orientation of the asci is similar to the ascogenous hyphae with the long axis in a radial direction.

The sterile matrix, into which the ascogenous hyphae

grow, breaks down early and is probably the main source of nutrition for the developing asci. The ascus walls break down very early in some species, allowing the ascospores to reach final maturity lying free in the matrix of the perithecial cavity; in other species, the ascus walls persist till maturity of the ascospores before breaking down. In either case, at maturity, the perithecial cavity is filled with the free ascospores which are extruded in a sticky ball at the mouth of the perithecium or as a long reddish-brown cirrhus which may exceed 5 mm. in length.

The ascospores are single-celled, uninucleate, and germinate either at one or both ends depending on the species. Single-spore cultures of some species indicate homothallism within the genus.

OCCURRENCE AND DISTRIBUTION

The habitat and geographical distribution of individual species is discussed under species descriptions; it is interesting, nevertheless, to consider the group as a whole in this respect.

Plant Pathogens

M. schumacheri, *M. cinereus*, *M. cirrosus*, *M. intermedius*, and *M. variabilis* have been isolated frequently from stored corn. While their presence is of little significance from the point of view of deterioration, they have been isolated so consistently that their function in this association is worthy of more serious study, especially since many of them are present in the apparently intact kernels independent of the presence of other organisms.

M. trigonosporus has been isolated by Whitehead *et al.* (38) from surface sterilized cereal and legume seed from Alabama, South Dakota, North Dakota, Michigan, Illinois, Minnesota, Iowa, Wisconsin, and Wyoming. From their experiments they note that the fungus persists within the enveloping tissue in dormant seeds of several crop plants and that blossom inoculation establishes the fungus in the pericarp tissues. They suggest that natural infection occurs the same way.

M. sordidus isolated by Curzi (7) from decayed *Prunus*

leaves has also been isolated from pepper and soybean seed in Canada. M. intermedius was first recorded as part of a complex associated with strawberry root rot.

Animal Pathogens

M. cinereus, M. lunasporus (sensu Jones), and M. trigonosporus have all been isolated from either dermal lesions or cases of onychomycosis in man. Furthermore, several of the fourteen species of Scopulariopsis listed by Dodge (8) as being pathogenic on man and animals have been described as producing abortive perithecia; under certain conditions such species may produce ascosporic forms.

Soil Fungi

In recent publications, M. cirrosus and M. trigonosporus have been listed, by Guillemat and Montegut (16) and Routien (31), respectively, as component organisms of the soil microflora. In recent years several hundred strains of Microascus species have been isolated from the soil, particularly M. intermedius but also including M. nidicola. In studies of the desert soils of Arizona and California, M. trigonosporus, M. cirrosus, M. Manginii and other species have been found. Indications are that, as in the case of many other fungi, the soil 'pool' of Microascus may be much greater than is at present supposed.

Coprophilous Fungi

The type isolates of both *M. longirostris* and *M. sordidus* were described by Zukal from mammalian dung. *M. variabilis* and *M. schumacheri* were also described from this medium by Massee and Salmon (25) and Hansen (17), respectively. *M. doguetii* has been isolated from dog dung in the United States and more recently several isolates of *M. guttulatus* have been received as having been isolated from deer dung in Ontario, moose dung in Wyoming, and partridge dung in Germany.

TAXONOMY

The genus Microascus was erected by Zukal (40,41) who described two species, M. longirostris and M. sordidus. The type species, M. longirostris, has a black, carbonaceous ascocarp with a well developed neck. The asci, which form a firm gelatinous ball within the perithecium, deliquesce early and liberate the small, red-brown, crescent-shaped ascospores into the perithecial cavity. The ascospores are extruded at maturity as a gelatinous ball at the mouth of the perithecium. M. sordidus differs from the latter species in both perithecial and ascosporic characters. Neither of the above species was studied in pure culture and Zukal did not connect them to conidial stages.

Thus the generic concept of Microascus is fairly well defined from Zukal's descriptions. Emmons and Dodge (11), Curzi (7), and others note that a number of species belonging properly to Microascus have been described under a variety of generic names of which the following were transferred to Microascus by Curzi: Sphaerella schumacheri Hans., Melanospora stysanophora Matt., Peristomium desmosporum Lech., Nephrospora manginii Loub., Scopulariopsis cinerea Emile-Weil and Gaudin, Acaulium nigrum Sopp, and Acaulium albo-nigrescens Sopp. Unfortunately, Cruzi gave neither reasons for these transfers nor descriptions of the species transferred.

Fuentes and Wolf (14) do not support Curzi in the trans-

fer of Sphaerella schumacheri and Melanospora stysanophora and regard the evidence as unconvincing. The writer has recently isolated a fungus from stored corn which corresponds so well with Hansen's original descriptions of Sphaerella schumacheri that they must be considered the same; this species undoubtedly belongs in Microascus. From the description of M. stysanophora given by Mattirolo and outlined herein, the writer is in agreement with Curzi that this species should also be assigned to Microascus. A recent study by Doguet (9) of a non-conidial isolate of this species indicates that it belongs in Microascus.

The Relationships between Microascus and Petriella

The genus Petriella, erected by Curzi to include four species, is very close to Microascus in a number of characters. The perithecia, papillate to long-necked, are characteristically invested with hairs. The asci, as in Microascus, are produced at all levels within the centrum and are evanescent. The ascospores moreover are red-brown, frequently asymmetric, and extruded at maturity in long cirrhi. Curzi separated Petriella from Microascus principally on the setose condition of the perithecium. He regarded Microascus as typically lacking such hairs and where they occur he regards them as being sparse and rhizoidal in function. The present work fails to support this distinction in that a number of

species recognized as being typical Microascus may show an abundant development of hairs. Observations show that the setose character is also considerably affected by environment and is therefore an undesirable character for taxonomic purposes.

The type species, P. asymmetrica Curzi, is of particular interest in its obvious similarities to M. sordidus Zukal. The ascospores of the two species (Plate 2, fig. 8; Plate 3, fig. 2) correspond almost exactly in size and shape. Moreover the perithecia of P. asymmetrica (Plate 11, fig. 4) are papillate to short-necked, agreeing very well with the figures of Zukal for M. sordidus (Plate 3, fig. 2). It appears from a careful comparison of P. asymmetrica with Zukal's descriptions of M. sordidus that the two species must be considered the same with the latter being prior.

The Large-spored Species of Microascus

Within the genus Microascus there are a number of species which are similar in that they all have relatively large ascospores. This large-spored group comprises the genus Petriella as defined by Curzi with the addition of M. sordidus (= P. asymmetrica), M. stysanophorus, and M. guttulatus including six species in all. Five of these species possess both Sporotrichum and Graphium conidial stages and the sixth has Stysanus and Sporotrichum as the conidial stages. None

of the small-spored group possess Graphium, Sporotrichum, or Stysanus as their conidial stage. Thus these large-spores species represent a distinct group within the genus. Whether they be separated as the genus Petriella emended or retained witnin the generic concepts of Microascus is perhaps a matter of opinion. It seems they are so similar to the remaining species of the genus in their fundamental characters that they should be regarded at best as sub-genus Petriella. The differences in the conidial stages is considered as of minor importance.

M. stysanophorus is of particular interest in its somewnat intermediate characters. It possesses a Stysanus conidial stage which is essentially a coremial form of Scopulariopsis and thus shows relationships to the small spored group. Observations on the ascospores of this species (Plate 2, fig. 5) show that again it is intermediate in character; while approximating the size range of the large-spored group, the ascospores lack the intensity of pigmentation and the bulk; they appear close morphologically to M. schumacheri of the small-spored group.

The sub-genus Petriella as outlined above contains the following species: M. sordidus, M. setifer, M. stysanophorus, M. boulangeri, M. lindforsii, and M. guttulatus.

Taxonomy of the Conidial Stages

Scopulariopsis Bain.

The genus Scopulariopsis was established by Bainier (2) with S. brevicaulis (Penicillium brevicaule Sacc.) as the type species. This genus includes a series of forms which differ from the true Penicillium in spore type, conidiophore, and colony characteristics. Apparently unaware of Bainier's monograph, Sopp (36) included essentially the same group of organisms in a new genus Acaulium. While Scopulariopsis is the prior name, Acaulium is of particular interest in that certain species were connected by Sopp to their ascosporic phase, characterized by the production of small carbonaceous perithecia with minute ostioles. Biourge (3) identifies this group of organisms with P. anomalum and places these forms in the sub-section Anomala of the genus Penicillium. Most workers agree that, as stated by Thom (37, p. 695):

> No one who has studied many strains of this group (i.e. Scopulariopsis) in comparison with the usual types of Penicillium pretends to believe in a close relationship between them.

The genus Phaeoscopulariopsis was established by Ota (29) to include two dematiaceous species of Scopulariopsis-like fungi, P. paisii and P. bestae. The erection of this new genus to include these species of Scopulariopsis with dark conidia is supported by Fuentes and Wolf (13). A new genus Masoniella (Masonia Smith) was established by Smith

(34,35) with the type species M. griseus. This genus is regarded by Hughes (18) as being synonymous with Phaeoscopulariopsis.

According to Hughes, in S. brevicaulis the sporogenous cells are anellophores. When young the anellophores are flask-shaped with short, almost cylindrical, necks; in older anellophores the necks are longer by virtue of the greater number of anellations. The conidia have a flattened base with a minute frill. Hughes notes that Masoniella grisea also produces chains of conidia through anellophores.

The conidia of both Scopulariopsis and Phaeoscopualriopsis (= Masoniella) are similar in shape and method of origin, being basally truncate and produced from anellophore type conidiophores. The only significant difference between these two genera is the color of the spores. The inclusion of these species with dark conidia into a new genus Phaeoscopulariopsis does not however seem justified. Pigmentation of the spores is not, in this instance, regarded as a generic character and species which are similar in all other respects must be placed in the same genus viz. Scopulariopsis with Phaescopulariopsis and Masoniella to be regarded as synonyms.

Morphology of the Conidiophores of *Scopulariopsis*

Observations on the morphology of the conidiophores in the species of *Scopulariopsis* associated with *Microascus* show that they can be divided into two basic types. The first type is characterized by having conidiophores which are simple or sparingly branched, fairly long, cylindrical in shape and frequently with a slightly swollen collar at the apical end as in *M. variabilis* (Plate 9, fig. 5). The second type of conidiophore is that which is generally recognized as being typical of *Scopulariopsis* being flask-shaped, broadest near the base or sometimes near the center and tapering towards both ends. The arrangement of the conidiophores in this second type is variable ranging from simple or whorled to the complex penicilloid arrangement found in *M. cinereus* (Plate 5, fig. 1).

In all cases studied the hyaline conidiophores and conidia (pure white colonies) have the simple conidiophore structure of the first type. All isolates with pigmented conidiophores and conidia have, with a single exception, conidiophores of the second type. The extent of this relationship to other species of *Scopulariopsis* is worthy of further study.

Speciation within the Genus

In the taxonomy of the Ascomycetes and their related conidial stages, a number of characters have been used to distinguish species. Ascocarpic, ascosporic, cultural and conidial characters have all been adjudged suitable criteria for speciation. Characters associated with sexuality are less subject to the effects of strain differences and environmental effects and are therefore much more desirable as taxonomic criteria. In the present study, the ascospore is regarded as the fundamental taxonomic unit for speciation. Observations show that the ascospores are the most constant character, not only in that they are little influenced by substrate or environmental conditions but also isolates from widely different geographical regions show good agreement in ascospore characters.

The Systematic Position of *Microascus*

Microascus was placed by Nannfeldt (28) close to *Ophiostoma* in the family Ophiostomataceae of the Plectomycetes. The relationships between *Microascus* and *Ophiostoma* were also appreciated by Luttrell (24); he, however, referred them to separate families, the Microascaceae and the Ophiostomataceae, respectively, of a new order the Microascales.

Microascus has been well established since Zukal char-

acterized M. longirostris and has remained a stable unit despite numerous revisions and controversies associated with related forms. Ophiostoma on the other hand has a complex history and has undergone a number of taxonomic and nomenclatorial reappraisals. Bakshi (1), would regard Ophiostoma as being synonymous with Ceratocystis, with the latter name having priority. Although this revision has been accepted and extended by Hunt (19), it is not yet generally accepted and the systematics of the genus are still in a state of flux. It would seem appropriate to take advantage of the stability of Microascus and include it in the Microascaceae of the Microascales after the fashion of Luttrell.

Microascus is included by Moreau (27), Emmons and Dodge (11), Doguet (9), and others in the Eurotiales on the basis of close similarities in the development and organization of the perithecial centrum. Undoubtedly the Microascales comprise a transitional group bearing close morphological resemblances to the Pyrenomycetes yet having the primitive centrum organization typical of the Plectomycetes. While the more fundamental characters of centrum organization would certainly include these forms in the Plectomycetes, the black, carbonaceous, ostiolate, frequently long-necked perithecia are sufficient, in the opinion of the writer, to exclude it from the Eurotiales.

The basic difference between Microascus and Ophiostoma

is in the centrum morphology. In Microascus the sterile matrix of the centrum is myceloid whereas in Ophiostoma it is pseudo-parenchymatous. Whether this difference is absolute is not yet known since only a few of the species of the two genera have been studied critically with respect to this character.

GENERIC DIAGNOSIS

MICROASCUS Zukal. Verhand. k.k. Zool. bot. Gesell. Wein 35: 333-342. 1885.

Perithecia superficial or immersed, produced singly or in clusters, mostly black and carbonaceous, sometimes membranous, spherical to pyriform, papillate to long-necked, ostiolate, fringe of ostiolar hairs sometimes present, glabrous to extremely hairy; setae hyaline to dark-brown, stiff or flexuous, smooth or covered with warty incrustations; paraphyses absent, periphyses usually present; asci globose to elliptic sometimes clavate, sessile or short-stalked, disposed at all levels within the centrum, evanescent, eight-spored; ascospores nonseptate, smooth, oval or asymmetrically convex or concavo-convex or plano-convex, sometimes triangular or tetrangular, disposed irregularly in the ascus, pale red-brown to dark red-brown in the mass, extruded from the mature perithecium in the form of a long reddish-brown cirrhus or as a gelatinous ball at the ostiole.

Conidial stages present in the majority of species, belonging to the form genera Scopulariopsis, or Stysanus and Sporotrichum, or Graphium and Sporotrichum.

TYPE SPECIES: Microascus longirostris Zukal

KEY TO THE SPECIES

1. Ascospores less than 8μ long or if longer less than 4μ broad.....2

2. Ascospores triangular or tetrangular in planar view.....3

3. Ascospores triangular, concave on all three sides, 3.5-5μ long.....1 *M. trigonosporus*

3. Ascospores 6-7μ long.....4

4. Ascospores triangular with broadly rounded ends, colonies restricted.....1 *M. trigonosporus* var. *macrosporus*

4. Ascospores triangular or tetrangular in planar view with tapering ends, colonies spreading.....2 *Microascus* sp. Orr 12

2. Ascospores ovoid, asymmetrically convex, plano-convex, or concavo-convex.....5

5. Ascospores ovoid.....6

6. Ascospores 5.5 by 3μ.....3 *M. desmosporus*

6. Ascospores 7 by 5μ.....4 *M. niger*

5. Ascospores asymmetrically convex, plano-convex, or concavo-convex.....7

7. Ascospores at least two times as long as broad.....8

8. Ascospores long and narrow, two and a half times as long as broad or longer.....9

9. Ascospores 5-7μ long.....5 *M. nidicola*

9. Ascospores 8-10μ.....10

10. Ascospores plano-convex to concavo-convex, conidial stage lacking.....6 *M. schumacheri*

10. Ascospores more convex on one side than the other, conidial stages Stysanus and Sporotrichum.....7 M. stysanophorus

8. Ascospores about two times as long as broad.....11

11. Conidial stage lacking.....8 M. intermedius

11. Conidial stage present.....12

12. Colonies pure white 9 M. albo-nigrescens

12. Colonies some other color.....13

13. Ascospores uniform in size and shape.....10 M. cinereus

13. Ascospores variable in size and shape.....11 Microascus sp. Orr 4

7. Ascospores less than two times as long as broad, usually abruptly concave.....14

14. Ascospores less than 3.5-4μ long.....12 M. variabilis

14. Ascospores greater than 4μ long.....15

15. Ascospores with a gelatinous sheath.....13 M. longirostris

15. Ascospores lacking a gelatinous sheath.....16

16. Colonies white.....17

17. Ascospores guttulate, conidia long and narrow.....14 M. lunatus

17. Ascospores not guttulate, conidia globose.....15 M. manginii

16. Colonies other than white.....18

18. Colonies brown, ascospores heart-shaped to broadly lunate, conidia striate.....16 M. doguetii

18. Colonies some shade of grey.....19

19. Ascospores variable, more often as broad as long, perithecia smooth 17 M. cirrosus

19. Ascospores variable, more often longer than broad, perithecia rough.11 Microascus sp. Orr 4

1. Ascospores greater than 8 by 4μ.....20

20. Ascospores plano-convex to concavo-convex.....21

21. Ascospores with numerous small oil droplets, perithecia short-necked.....18 M. sordidus

21. Ascospores with a few large oil droplets, perithecia papillate and extremely setose.....19 M. guttulatus

20. Ascospores ovoid or asymmetrically convex.....22

22. Ascospores asymmetrically convex.....23

23. Ascospores guttulate with apical germ pores, perithecium membranous...20 M. setifer

23. Ascospores lacking germ pores, perithecium black, carbonaceous.7 M. stysanophorus

22. Ascospores ovoid.....24

24. Ascospores with pointed ends.....21 M. lindforsii

24. Ascospores with rounded ends.....22 M. boulangeri

SPECIES DESCRIPTIONS

1. MICROASCUS TRIGONOSPORUS Emmons and Dodge. Mycologia 23: 313-331. 1931. (Plate 1, fig. 8; Plate 8, figs. 1-5; Plate 12, fig. 1)

Perithecia black, carbonaceous, glabrous or with scattered hairs, flask-shaped, with spherical base, 125-250μ in diameter; neck up to 250μ long, cylindric or tapering, sometimes swollen at the tip trumpet-like, smooth or with well marked protuberances giving a rough outline; asci sub-globose to ovoid 6-9 by 9-12μ, sessile; ascospores triangulate, concave on all three sides, 2.5-3.5 by 3.5-5.5μ, broadly rounded at the ends, red-brown in mass.

Conidial stage Scopulariopsis; vegetative hyphae hyaline to dark-brown, anastomosing to form 'ropes', funiculose habit more pronounced in some isolates; conidiophores mostly long and narrow, 10-15 by 2-3μ, broadest between the center and the base, tapering towards both ends, borne singly or in whorls, occasionally branching and approaching a penicilloid habit; conidia variable in size and shape, globose, sub-globose, ovoid or lemon-shaped, narrowly truncate at the basal end, rounded to papillate at the apical end, 2.5-3.5 by 3.5-5.5μ.

From: skin lesion. Porto Rico; soybeans, Alabama; barley, South Dakota, North Dakota, Michigan, Illinois, Minnesota, Iowa, and Wisconsin; sorghum, Kansas; desert soils, California; mouse, Arizona.

Culturally this species shows the greatest variation of any species of Microascus so far studied; wide differences occur between isolates from different substrates and geographical locations. Growth may be restricted or spreading, zonate or azonate, regular or irregular in outline. Colonies from different isolates also vary considerably in color, from dirty white through light-grey to dark-grey; some are distinctly brownish. Conidial production varies considerably from sparse to abundant.

Morphological variations between isolates are also in evidence. In some strains the perithecia are extremely long-necked while in others they are papillate to short-necked. Ascospores may be equilateral or distinctly longer on one side. Conidia show variability both within and between isolates; in some isolates they may be mostly globose while in others mostly lemon-shaped.

Despite the variations shown by these strains in both morphological and cultural characters they all have the same basic similarity in triangulate ascospores and are considered merely as different facets of the same species.

M. trigonosporus Emmons and Dodge var. macrosporus Orr. (Plate 1, fig. 7)

This strain is basically the same as M. trigonosporus in many of its characters but is distinct in having ascospores and conidia which are half as large again in linear dimensions. The ascospores measure 5-6.5 by 5.5-7.5μ with the

asci being proportionately larger. The perithecia of this large-spored strain are similar in size and shape to the normal. Conidia measure 4-5 by 5-7μ and are narrowly truncate at the base and rounded to papillate at the apical end. Conidiophores are narrow and out of proportion to the conidia which they bear, being 2-3μ broad and cylindrical to irregularly flask-shaped. Certain conidiophores and some of the conidia appear abortive and devoid of protoplasmic contents. The vegetative hyphae exhibit vesicular swellings in numerous places along their length.

Colonies show a restricted growth on P.D.A.; at first white later turning brownish-grey with the production of conidia, particularly round the perimeter of the colonies. Colonies are raised in the center with radial wrinkling of the agar. Perithecia are produced abundantly; the central regions turn black with perithecia and later red-brown with the extrusion of numerous cirrhi.

This form, isolated from the desert soils of California by G. F. Orr, can be identified in all morphological characters with M. trigonosporus with which it seems to have a close genetic relationship, differing in its fundamental characters only in size. It is considered as a large-spored strain rather than a distinct species.

2. MICROASCUS SP. (Orr 12). (Plate 1, fig. 9)

Perithecia flask-shaped with a spherical base, 125-250μ in diameter, black, carbonaceous, sparingly setose; neck 100-200μ long, cylindrical, frequently trumpet-shaped at the top with a tuft of ostiolar hairs, rough in outline; setae hyaline to dilute-brown colored, up to 100μ long, smooth, septate; asci sub-globose to ovoid, 9-12 by 13-18μ; ascospores triangular or tetrangular in planar view, frequently with thickenings on the sides extended to points to give the ascospores a rough diamond shape with concave sides, narrowly tapering with rounded ends, pale golden yellow, red-brown in the mass, 5-6.5 by 5.5-7μ.

Conidial stage Scopulariopsis; vegetative hyphae anastomosing to form ropes; pale to dark-brown pigmented; conidiophores borne on strands and hyphae singly or in groups, rarely approaching a penicilloid habit; conidiophores long and narrow, broadest at the center tapering toward both ends, sometimes broadest near the base and flask-shaped; vegetative hyphae and conidiophores frequently finely roughened; conidia markedly truncate, papillate or rounded at the apical end, frequently with a distinct waist, 3-4 by 4.5-5.5μ, pale grey-brown.

Recorded only once from soil in California.

On P.D.A. colonies reach a diameter of 4-5 cm. in four weeks. Growth is strongly funiculose with hyphal strands

being orientated in a radial direction. Colonies grey to violaceous grey, turning brownish in age, with a raised button in the center, and accompanied by radial wrinkling of the agar. A clear exudate is produced particularly near the center. Perithecia are produced abundantly, at first in the aerial hyphae and later in and on the agar round the perimeter of the colonies.

This species is closest to M. trigonosporus var. macrosporus from which species it is distinguished by the distinctive ascospores, the smaller conidia and the growth habit.

3. MICROASCUS DESMOSPORUS (Lech.)Curzi. Boll. Staz. Pat. veg. Roma 11:55-60. 1931.

Syn. Peristomium desmosporum Lechmere. Bull. Soc. Mycol. France 39:303-331. 1913.

Perithecia dark, membranous, spherical in shape, 160-200 μ in diameter, papillate, glabrous to slightly hairy; asci ovoid, evanescent, 6-7 by 13-14 μ; ascospores ovoid, 4-5 by 3 μ, slightly pointed at the extremeties, reddish-brown in color, extruded at maturity of the ascocarp in the form of a long cirrhus.

Two distinct forms of this species were described by Lechmere. The first of these produces abundant conidia of the Scopulariopsis type; the second lacks a conidial stage but produces numerous thick-walled chlamydospores.

Conidial form: conidial stage belonging to Scopulari-

opsis; vegetative hyphae hyaline to lightly pigmented, bearing conidiophores along their length; conidiophores produced singly or in whorls, mostly 5-10μ long, cylindrical or more often flask-shaped; conidia with a well marked truncate basal end and rounded or papillate at the apical end, 3.5-4.5 by 2.5-3.5μ, pale grey in color.

Chlamydospore form: vegetative hyphae mostly subsurface, at first white later acquiring a blackish color; certain cells enlarging, becoming thick-walled and rounding off to form chlamydospores; chlamydospores dark-brown colored, terminal or intercalary, single or in chains, measuring on the average 8 by 5μ.

From the Ivory Coast, Africa. No other recording of this species has been noted.

Peristomium desmosporum was described as a new genus and species by Lechmere (21) who associated his isolates with both a Verticillium and an Oidium imperfect stage. Curzi (7) and Emmons and Dodge (11) noted correctly that what Lechmere figured as a Verticillium might well be a Scopulariopsis, since the figures show the conidia arising in short chains. According to modern terminology what Lechmere describes as oidia must be regarded as chlamydospores. The type cultures no longer produce ascospores but from the descriptions of the ascosporic phase as given by Lechmere, there is little doubt that Curzi was correct in transferring

it to Microascus.

Only two species of Microascus in the small spored group have been described with ovoid ascospores, the other being M. niger. M. desmosporus is readily distinguished from the latter species in having smaller ascospores and a distinct conidial stage.

4. MICROASCUS NIGER (Sopp)Curzi. Boll. Staz. Pat. veg. Roma 11:55-60. 1931.

Syn. Acaulium nigrum Sopp. Vidensk. Skrifter. Mat. Naturv. Klasse No. 11. 1912.

> Colonies brown toward black, color potato and gelatine blue-black, in gelatine cultures remaining long-submerged in the liquefied brown mass, ultimately producing conidial areas about the margin and over most of the surface which is irregular or rough and wrinkled; in very old colonies successive new growths overlay each other to form deep masses; hyphae delicate upon the usual media Streptothrix-like; conidiophores often wanting, occasionally present and Penicillium-like, especially in young cultures upon potato, branching at the summit one, two, or three times to produce a tangled often winding mass of sterigmata, bearing long chains of conidia; sterigmata frequently sessile on mycelial hyphae, especially in old cultures; conidia large, irregular echinate, angular, almost polygonal, thick-walled, at first biolet-brown then various shades of red, chocolate, and coffee-brown to black-brown, 7-8μ in diameter; perithecia produced most readily on potato, at first olive-green, then black, sunk in the mycelium, with definite ostiole; ascospores eight to the ascus, smooth, oval, almost sharp-pointed, brown, 7 by 5μ.
>
> The species was parasitic upon insect larvae especially Gastropacha pini and recoverable from earth samples in the infected area; it was reported from various places in Norway; upon the larvae, colonies form a thin close woven mycelial layer, which is densely covered with sessile sterigmata.

The above description is from Thom's (37, p. 534) monograph of the Penicillia. The species as described is closest to M. desmosporus but differs in having larger ascospores and a distinct conidial phase.

5. MICROASCUS NIDICOLA Massee and Salmon. Ann. Bot. 15:313-357. 1901. (Plate 2, fig. 3; Plate 3, fig. 3; Plate 12, fig. 6)

Perithecia black, carbonaceous, glabrous, nearly spherical in shape, 75-150μ in diameter, with a very short cylindrical neck; asci ovoid to clavate, sessile, 10-17 by 5-8μ; ascospores long and narrow, 6.5-8 by 1.5-2μ, plano-convex to markedly concavo-convex with rounded ends, pale straw colored. No conidial stage known.

From: wasp's nest, England; soil, Utah; Dipodomys merriami, Utah.

On P.D.A. the colonies are restricted reaching a diameter of only 2-3 cm. in several weeks. At first white, they rapidly turn black with the production of numerous perithecia over the entire colony save for a narrow white fringe of sterile floccose hyphae. There is a raised button at the center of the colonies accompanied by radial wrinkling of the agar. Perithecia are produced in profusion being several layers deep in older parts.

This species shows a close morphological resemblance to M. schumacheri in both the shape of the ascospores and the perithecia. In the latter species, however, the ascospores

are distinctly larger, guttulate, and less markedly concave. None of the three cultures of M. nidicola examined by the writer produced a conidial stage nor was one described by Massee and Salmon in the original paper.

6. MICROASCUS SCHUMACHERI (Hans.)Curzi. Boll. Staz. Pat. veg. Roma 11:55-60. 1931. (Plate 2, fig. 4; Plate 7, figs. 1-4)

Syn. Sphaerella schumacheri Hans. Videnskab. Meddelelser Kopenhagen 1.c:37-71. 1876.

Rosellinia schumacheri (Hans.) Sacc. Sylloge Fungorum Vol. 1. 1882.

Perithecia black, carbonaceous, 150-300μ in diameter, nearly spherical with very short truncate necks, glabrous or covered with scattered hairs; asci ovoid, sessile, 13-20 by 7-9μ ; ascospores, long and narrow, 7.5-9 by 2.5-4μ plano-convex to slightly concavo-convex with rounded ends, guttulate with numerous small oil droplets, pale straw colored, reddish-brown in mass. No conidial stage known.

From: dung of rabbits, rats and mice, Denmark; stored corn, Iowa.

M. schumacheri grows very poorly on all media tried. On C.M.A. a stromatic-like crust is formed reaching a diameter of 1/2-1 cm. in four to six weeks. Perithecia are produced in abundance in the crustose colony. Vegetative hyphae are irregular, extremely vesiculose along much of their length, and contain numerous oil globules. No conidial stage was found associated with any of the isolates obtained.

The isolates from corn differ from Hansen's original descriptions in having larger setose perithecia and slightly smaller ascospores. The relationship of this species to M. nidicola is discussed under the latter species. M. schumacheri is close to M. stysanophorus but is distinct in having narrower, slightly concavo-convex ascospores.

7. MICROASCUS STYSANOPHORUS (Matt.)Curzi. Boll. Staz. Pat. veg. Roma 11:55-60. 1931. (Plate 2, fig. 5)

Syn. Melanospora stysanophora Mattirolo. Atti R. Acad. Scienze Torino 21:273-282. 1886.

Perithecia dark-brown to black, short-necked, spherical to pyriform, 180-200μ in diameter; asci ovoid; ascospores yellowish, transparent, more convex on one side, 9-10 by 5-6μ.

Conidial stages belonging to the form genera Stysanus and Sporotrichum; vegetative hyphae branching freely, producing numerous conidia on short conidiophores of the Sporotrichum type; conidia acrogenous, hyaline, borne singly on short spicules, wedge-shaped, 9-12 by 5-6μ. Stysanus stage produced readily; lateral growing branches perpendicular to the surface becoming corticated to form coremia; coremial hyphae branch profusely at the top to produce an elongate sporiferous head; conidia hyaline, lemon-shaped, borne in chains. In some cases conidia borne directly on the vegetative hyphae as in Scopulariopsis.

This species was redescribed by Guégen (15) who noted

with rounded ends, 2-3 by 4.5-6μ. No conidial stage known.

From: diseased strawberry roots, North Carolina; soil, Georgia, New York, Utah, and Virginia; stored corn, Iowa.

Growth is restricted on all media used; colonies reach a diameter of 1.5-2.5 cm. in four weeks on C.M.A. Vegetative growth is mostly sub-surface with little aerial mycelium. Perithecia are produced abundantly over the colonies scattered or in concentric rings.

Ten isolates of this species have been examined in culture and the characters as outlined above are very constant. No conidial stage has been described for this fungus and it seems unlikely that such a stage exists. In ascospore dimensions it approaches M. cinereus and M. albo-nigrescens. It is distinguished from M. cinereus by its narrower, more convex, paler, ascospores and from both species by the absence of a conidial stage.

9. MICROASCUS ALBO-NIGRESCENS (Sopp)Curzi. Boll. Staz. Pat. veg. Roma 11:55-60. 1931.

Syn. Acaulium albo-nigrescens Sopp. Vidensk. Skrifter. Mat. Naturv. Klasse No. 11. 1912.

> Colonies chalk-white with coremium-like white hyphal bundles bearing conidial masses either on short conidiophores or sessile, and giving a mealy white appearance followed by the progressive development of black perithecia until the whole colony appears as a coal-black wrinkled mass of black bodies with areas of white showing among them; the underside is also black at this stage; conidiophores produced typically as branches from ropes, bundles, or coremia, forming Stysanus-like columns, branching of conidiophores in several superposed verticils with elements

> progressively smaller in diameter; sterigmata long and tapering to a very narrow apex at the conidium-bearing tube, from which arise long diverging conidial chains; conidia white, recorded as 10 by 10μ, but figured as narrowly elliptical, possibly 10 by 5μ; which become globose in germinating; perithecia arising as characteristic coils of hyphae involving the tips of several adjacent branches; olive-green then coal-black produced in great abundance ripening in several weeks and extruding their ascosporic masses through fine pores as a pale coffee brown powder (ascospores) covering of the whole surface; some perithecia are superficial, others immersed in mycelial masses; ascospores about 6 by 4μ, fairly thick walled, oblique or concave on one side, brown, 8 to the ascus, extruded in slimy masses from the perithecia, and germinating slowly.
>
> Species found first as a chalk-white growth upon milk in a cellar in Norway, and later in a compost heap, and in old goat cheese.

The above description is from Thom's (37, pp. 516-517) monograph of the Penicillia. The culture of this species from the C.B.S. no longer produces ascospores and the vegetative growth is atypical, thus no attempt has been made to redescribe it. Conidia were found in some mounts which agreed in general with the discussion above.

M. albo-nigrescens bears a close resemblance to both M. cinereus and M. intermedius in ascospore shape and size. It seems to be distinct from the above species in its pure white Scopulariopsis stage with comparatively large conidia. The precise differences between this and similar forms cannot be described since a fruiting culture of this species has not been examined.

10. MICROASCUS CINEREUS (Emile-Weil and Gaudin)Curzi. Boll. Staz. Pat. veg. Roma 11:55-60. 1931. (Plate 2, fig. 1, Plate 5, figs. 1-4)

Syn. Scopulariopsis cinerea Emile-Weil and Gaudin. Arch. Med. de Exp. et Anat. Path., Paris 28:452-467. 1919.

Perithecia black, carbonaceous, scattered or crowded, globose, 100-250μ in diameter, papillate, glabrous or with scattered hairs; hairs septate, pigmented, encrusted with wart-like protuberances; asci sessile, mostly elliptical, sometimes globose, rarely clavate, 10-14 by 7-10μ; ascospores liberated early into the central cavity, plano-convex to slightly concavo-convex with rounded ends, pale red-brown, 5-6.5 by 3-4μ.

Conidial stage Scopulariopsis; conidiophores arising from the vegetative hyphae singly or in groups, frequently in a complex penicilloid arrangement; funiculose habit strongly marked with hyphal ropes bearing numerous conidiophores along their length; conidiophores broader at the center tapering towards the extremities, usually 6-12μ long sometimes almost obsolete; conidia borne in long chains, markedly truncate at the basal end, obtusely rounded at the tip, sometimes papillate, 3.5-5 by 3-4μ, pale greyish-brown in color.

From: infected big toe, France; stored corn, Iowa; mammalian dung, Ontario; chromoblastomycosis patient, Cuba; oats, Kansas.

This species grows well on P.D.A. reaching a diameter

of 4-6 cm. in four weeks. Colonies are greyish to olivaceous-grey when young, becoming progressively browner in age. The funiculose habit is well marked on this medium giving the cultures a mealy appearance. Younger colonies produce a clear exudate in the form of small droplets over the surface of the colonies and particularly towards the center. Perithecia are produced abundantly within a few weeks; obscured at the center by the thick vegetative growth, they appear as small black dots towards the outside of the colonies where the turf is thinner. The perithecia may be scattered evenly over the colony but are frequently produced in concentric rings.

Certain isolates of this species fruited on the cotton wool plugs of the culture tube. The perithecia produced under these circumstances tend to be long-necked with the necks variously bent and misshapen. Perithecia have never been observed to form necks under normal cultural conditions.

M. cinereus is one of the most common species in the genus. It is of wide geographical distribution and substrate range. All cultures examined conform well with the description given above. Strains from quite different substrates and locations are fairly constant in ascosporic, perithecial, and conidial characters.

The ascosporic phase of this species was erroneously connected to Hormodendrum pedrosoi by Fuentes and Wolf (13,

14) who later reassigned it as M. cinereus. As given by these workers the ascospori dimensions are somewhat exaggerated (8.4-10 by 3.2-3.8μ) and the range given by Emile-Weil and Gaudin agrees more closely with the cultures examined. The possible relationship between M. cinereus and M. lunasporus is discussed under the latter species. M. cinereus closely resembles M. intermedius in ascospore shape and size; the ascospores of the latter species are somewhat slimmer, more markedly concave, and paler in color.

11. MICROASCUS SP. (Orr 4). (Plate 1, fig. 5; Plate 11, fig. 2; Plate 12, fig. 4)

Perithecia black, carbonaceous, flask-shaped with a spherical base, 200-300μ in diameter, rough in outline, setose; neck straight and cylindrical or variously twisted and misshapen, up to 200μ long, frequently with a tuft of hyaline ostiolar hairs; setae twisted and somewhat matted round the perithecium, septate, dark-brown colored, up to 150 long, sometimes with warty incrustations; asci subglobose to ovoid, sessile, 6-10 by 10-13μ, ascospores variable in size and shape, 2-3.5 by 4-5.5μ, kidney-shaped, heart-shaped, allantoid, sometimes approaching triangulate, dilute-brown in color.

Conidial stage Scopulariopsis; vegetative hyphae at first hyaline later becoming brown pigmented, anastomosing to form ropes; condidiophores borne directly on the vegetative hyphae, simple or sparingly branched, mostly cylindrical,

sometimes irregularly flask-shaped, up to 20μ long, slightly swollen at the tip to form an apical collar; conidia variable in shape, 2.5-3.5 by 4.5-5.5μ, basally truncate, rounded or papillate at the apical end, frequently with a waist near the base, pale greyish-brown color.

From: desert soils, human lung, skunk dung, California.

On P.D.A. colonies grow slowly reaching a diameter of 4-6 cm. in four weeks. Some isolates produce abundant conidia others are largely sub-surface in their vegetative growth with little conidial development; thus different isolates vary considerably in appearance. Conidial bearing colonies are pale greyish in color, extremely funiculose at the center, becoming less so towards the perimeter; sectoring into conidial and non-conidial regions is common. Perithecia are scattered in the aerial hyphae and on the agar in the non-conidial sectors. In isolates with limited conidial production the colonies remain light-colored with perithecia produced on the agar, scattered evenly over the surface or tending to a zonate production in concentric rings.

This species differs from M. cirrosus in having a distinctly roughened perithecium, more kidney-shaped ascospores, and long-cylindrical conidiophores.

12. MICROASCUS VARIABILIS Massee and Salmon. Ann. Bot. 15: 313. 1901. (Plate 1, fig. 4; Plate 9, figs. 1-6; Plate 12, fig. 5)

Perithecia flask-shaped, with a spherical base up to

300μ in diameter, black, carbonaceous, extremely setose; neck variable in length, up to 600μ but usually between 100-200μ long by 20-30μ broad, sometimes papillate, somewhat trumpet-shaped at the tip with a fringe of hyaline ostiolar hairs; perithecial setae stiff, straight, numerous, dark-brown colored, septate, covered with numerous wart-like protuberances; asci sessile or produced in short chains, small, globose to sub-globose, 8-10μ in diameter; ascospores uniform small, 3-4 by 2.5μ, abruptly concave on one side, dilute-brown colored.

Conidial stage Scopulariopsis; vegetative hyphae hyaline, anastomosing to form hyphal ropes; conidiophores borne along the length of hyphae and ropes, simple or branched dichotomously, cylindrical, straight or somewhat contorted, slightly swollen collar at the tip; conidia hyaline, well marked truncate basal end, rounded or tapered at the apical end, sometimes with a well marked waist, 4-6 by 3-4μ. This represents the first recording of the conidial stage of M. variabilis.

From: dung, England; stored corn, Iowa; wasp's nest, New York.

M. variabilis grows slowly on C.M.A. reaching a diameter of 2-3 cm. in 3-4 weeks. Vegetative growth is mainly subsurface with aerial hyphae scant. Conidial production is largely suppressed on this medium. Perithecia begin to appear in a few weeks and are produced in abundance at first

at the point of inoculation, later in concentric zones around the point of inoculation. On P.D.A. the fungus grows slowly; a floccose white mycelium is produced round the point of inoculation composed largely of conidial bearing hyphae; perithecia are again produced in concentric zones with a clear zone of sub-surface hyphae around the perimeter of the colonies.

This species shows considerable variation in culture. Some isolates grow well and fruit abundantly, others may fail to fruit or sector into sterile and fertile regions. A number of cultures which fruited abundantly when first isolated lost the ability to do this after a few transfers; such cultures produced small black sclerotial like bodies which were apparently abortive perithecia. A few isolates produce large numbers of perithecia below the surface of the agar particularly on 20% Czapek's agar. Such perithecia were characterized by extremely long necks (up to 1 mm.) and were devoid of setae.

M. variabilis has the smallest ascospores of any species of Microascus so far studied. It is close to M. lunatus in ascospore shape and size but differs from this species in its smaller, less variable, non-guttulate ascospores and its long-necked, setose perithecium.

13. MICROASCUS LONGIROSTRIS Zukal. Verhand. k.k. Zool. bot. Gesell. (Wein) 35:333-342. 1885. (Plate 3, fig. 1)

Perithecia black, carbonaceous, single or gregarious,

spherical in shape, about 400μ high and mainly sunken in the substrate; neck cylindrical, fringed with stiff hairs, sometimes extended trumpet-like, 150-200μ long by 18-24μ wide, asci sessile, eight-spored, measuring about 30-36μ, degenerating early; ascospores crescent-shaped, transparent brown, smooth, 4-5 by 2-3μ, surrounded by a delicate gelatinous sheath, spores extruded in the form of a gelatinous ball.

From dry dung and rotting wood in contact with the faecal masses.

M. longirostris is of special significance since it is the type species of the genus; unfortunately neither a type culture nor type herbarium material is available for study. The culture assigned to this species in the C.B.S. culture collection more closely approaches M. variabilis to which it has been reassigned. Crescent-shaped ascospores with a gelatinous sheath have not been described for any other species of Microascus and the possibility of this sheath being an artifact cannot be excluded. M. longirostris must be recognized on the basis of Zukal's work and the fungus corresponding to his descriptions may eventually be rediscovered.

M. lunatus is the closest to this species but differs from it not only in the finer points of ascospore morphology but also in perithecial characters having a papillate to

short-necked, sparingly setose perithecium.

14. MICROASCUS LUNATUS sp. nov. (Plate 1, fig. 1; Plate 12, fig. 2)

Perithecia black, carbonaceous, spherical to pyriform, papillate to short-necked, 200-500μ in diameter, with scattered setae; setae mostly short, up to 40μ long, dark, smooth; asci sub-globose to ovoid, 8-12 by 6-10μ, eight-spored, walls disappearing very early; ascospores lunate with rounded ends, 3.5-5 by 2-3.5μ, guttulate, red-brown in mass, extruded at maturity in the form of a gelatinous ball at the mouth of the perithecium or as a long cirrhus.

Conidial stage Scopulariopsis; vegetative hyphae hyaline, containing numerous oil droplets; conidiophores mostly simple, sometimes branching, cylindrical or tapering from the middle to the apex, variable in length, mostly between 15-30μ long, sometimes almost obsolete; conidia long and narrow, 7-9.5 by 2-3.5μ, rectangular in shape, basally truncate, hyaline; borne in short, fragile chains.

Colonies grow rapidly on P.D.A. reaching a diameter of 6-8 cm. in four weeks. The turf is thin, white, slightly floccose, sometimes sectoring into fertile and sterile regions. Perithecia are produced within a few weeks, at first scattered, later evenly and thickly over the whole surface giving the white colonies a broad black border in age.

M. lunatus is close to both M. variabilis and

M. longirostris. It differs from both species in having a short-necked, sparingly setose perithecium. It lacks the gelatinous sheath of M. longirostris and differs from M. variabilis in having larger, guttulate ascospores and a distinctive conidial stage.

M. lunatus was one of two isolates deposited at Peoria by R. Thaxter as M. vesparius. The first of these isolates was found to be identical with M. variabilis; the second is described above. Thaxter gave no description of M. vesparius and the name was apparently assigned for herbarium purposes.

15. MICROASCUS MANGINII (Loub.)Curzi. Boll. Staz. Pat. veg. Roma 10:55-60. 1931. (Plate 1, fig. 6; Plate 11, fig. 6; Plate 12, fig. 3)

Syn. Nephrospora manginii Loub. Théses presentées à la Faculté des Sciences de Paris. Ser A No. 982. 1924.

Scopulariopsis albo-flavescens Zach. Osterr. Bot. Ztschr. 82:173-186. 1934.

Perithecia spherical, dark-brown to black, carbonaceous, papillate, glabrous, 100-175μ in diameter; asci spherical to ovoid, sessile, 8-12 by 12-16μ; ascospores uniform in size and shape, almost as broad as long, somewhat heart-shaped 4-5 by 5-6μ, markedly concave, pale red-brown.

Conidial stage Scopulariopsis, vegetative hyphae hyaline, bearing numerous conidiophores; conidiophores long and cylindrical, simple or sparingly branched, mostly 10-20μ long; conidia large, thin-walled, hyaline, globose to subglobose, markedly truncate and sometimes with a waist at

the basal end, rounded to papillate at the apical end, 5-6 by 6-8μ.

Colonies grow rapidly on P.D.A. reaching a diameter of 5-6 cm. in a few weeks; forms a white cottony mycelium which becomes thicker and exudes droplets of amber or colorless fluid at the surface. In age colonies appear slightly yellowish and mealy. Some isolates show a sparse production of conidia. Most of the vegetative growth being sub-surface and conidial production restricted to the center. Peritheca are produced abundantly and tend to be zonate in concentric rings.

M. manginii is readily distinguished from all other species by the uniform heart-shaped ascospores, the papillate perithecium and the distinctive conidial phase.

16. MICROASCUS DOGUETII Moreau. Rev. de Mycol. 18:165-180. 1953. (Plate 1, fig. 3; Plate 4, figs. 5 and 6)

Perithecia spherical, black, carbonaceous, 150-300μ in diameter, covered with short hairs or nearly glabrous, usually with a well developed neck; neck 25-150μ long, more or less hairy; asci oval to elliptical 10-20 by 7-15μ, ascospores heart-shaped to broadly lunate, 5-7 by 4-7μ, with rounded ends, red-brown in the mass.

Conidial stage Scopulariopsis; conidiophores usually short, mostly between 5-10μ long, borne singly or in groups, cylindrical to flask-shaped, frequently contorted; conidia 4-7 by 3.5μ, truncate basal end well marked, rounded at the

apical end, brown in color, with one to five narrow bands running at an angle along the length of the conidia giving them a striate appearance.

Found as a contaminant, Caen, France. Recorded in U.S.A. by R. Thaxter as M. longirostris; source not known.

Colonies grow slowly on P.D.A. reaching a diameter of 3-4 cm. in four weeks. Growth at first mostly sub-surface showing markedly zonate habit of several concentric rings. At first white, colonies become distinctly brown and funiculose in the conidial bearing regions, particularly near the center. Conidial production lags considerably behind the vegetative growth. Perithecia are produced abundantly in a few weeks scattered over the surface, or in the aerial hyphae, sometimes in concentric rings.

This species resembles M. cirrosus somewhat in shape of ascospores but those of M. doguetii are less variable and slightly larger. The shape of the perithecia and the character of the conidial stages also serve to distinguish readily between the two species. The American culture has a higher frequency of heart-shaped ascospores than the European isolate which tends to the broadly lunate shape. The two isolates however agree well in other respects particularly in the brown color of the colonies and the similarities of the conidial stage.

17. MICROASCUS CIRROSUS Curzi. Boll. Staz. Pat. veg. Roma 10:302-310. 1930. (Plate 1, fig. 4; Plate 6, figs. 1-5)

Perithecia black, carbonaceous, glabrous to sparingly setose, about 100-250μ in diameter, flask-shaped with a spherical to sub-globose base and a well developed neck; neck somewhat swollen at the tip measuring up to 200μ long by 20-40μ broad; setae smooth, pigmented; asci globose to ovoid in shape, measuring 8-11 by 10-15μ; ascospores variable in size and shape, 3.5-5.5 by 4-6μ, concavo-convex, sometimes irregularly angular, rarely triangular in shape, dilute brown in color.

Conidial stage Scopulariopsis; conidiophores arising singly or in groups, forming whorls of three to five at the end of short lateral branches, occasionally penicilloid, sometimes almost obsolete; vegetative hyphae anastomosing to form dark 'ropes' bearing conidiophores along their length; conidiophores broader at the center narrowing towards both ends; conidia produced in long chains, basally truncate character not as well seen in this species, globose to subglobose in shape, rounded sometimes slightly pointed at the ends, measuring 3.5-4.5 by 3-4μ, pale grey-brown in color.

From: decayed Prunus leaves, Italy; stored corn, Iowa; soil, France; flax seed, Ontario; desert soil, California; oats, sorghum, Kansas.

This species grows rather slowly on C.M.A. reaching a

diameter of 3-4 cm. in a few weeks at room temperature. At this time the colonies are dark olivaceous-grey in color turning to olivaceous-brown and finally brown in age. Young cultures exhibit a clear exudate as small droplets over the surface particularly round the perimeter. Colonies have a mealy appearance due to the funiculose habit of the growth and may be markedly zonate, uniform, or sector into light (conidial) and dark (non-conidial) areas. Older colonies become dotted with small white tufts of floccose sterile hyphae. Perithecia are produced abundantly in a few weeks either scattered evenly over the surface, in concentric rings, or confined to the non-conidial sectors of sectoring isolates. Ascospores may be produced in such abundance as to give a reddish tinge to the entire colony.

On P.D.A. the colonies have a much thicker turf with the funiculose habit more strongly pronounced. The colonies have a raised button in the center and frequently cause radial wrinkling of the agar. Culturally this species is very close to M. cinereus but differs in the darker color and less stable habit.

M. cirrosus shows a wide variability in ascospore shape and size within and between isolates; many of the ascospores are irregular and some approach the triangulate condition of M. trigonosporus. The species as outlined above would cover an assemblage of forms basically similar in that their vari-

able ascospores cover the same range of size and shape but differing in the proportions of the various types.

18. MICROASCUS SORDIDUS Zukal. Ber. deuts. bot. Gesell. 8:295-303. 1890. (Plate 2, fig. 8; Plate 3, fig. 2; Plate 11, fig. 3)

Syn. Petriella asymmetrica Curzi. Boll. Staz. Pat. veg. Roma 11:380-423. 1931.

Perithecia black, carbonaceous, papillate to long-necked, with spherical base, 200-400 μ in diameter; neck frequently half as long as diameter of base, sometimes longer and contorted, up to 400 μ; perithecia and neck covered with scattered hairs; hairs short and straight on neck, longer and undulate on base, septate, brown-pigmented, smooth or with wart-like protuberances, up to 100 μ long; asci sub-globose to ovoid, frequently clavate with a well developed foot, 18-28 by 11-19 μ; ascospores plano-convex to slightly concavo-convex, 4.5-5.5 by 8.5-10.5 μ, red-brown, containing numerous small oil droplets, extruded in a long dark-brown cirrhus.

Conidial stages Sporotrichum and Graphium; Sporotrichum conidial stage arising first; conidiophores originating from the vegetative hyphae or hyphal 'ropes', simple, long, slender, tapering, bearing conidia singly and acrogenously on short spicules; conidiophores and conidia hyaline, conidia mostly pyriform, sometimes wedge-shaped or long-cylindric, tapering sharply to a narrow base, rounded at the apical end, 3.5-5.5 by 4.5-8.5 μ. Graphium stage soon in evidence;

vegetative hyphae grow perpendicular to the substrate, anastomose and corticate to form coremia; coremia dark-brown pigmented, up to 1 mm. high and 200μ broad, sterile hyphae branching at the top to form a sporiferous head; conidia arising as Sporotrichum type but are released in a mucous material which appears as large gelatinous balls at the top of the coremia; gelatinous heads at first hyaline later becoming violaceous and finally sooty in age; conidia measure 2.5-4.5 by 8-14μ, usually long-cylindric, sometimes wedge-shaped or pyriform.

From: soil, Colorado; pear tree, Italy; soybean seed, Manitoba; pepper seed, Ontario.

Colonies reach a diameter of 4-6 cm. in four weeks on P.D.A. At first white, colonies turn greyish in the central portions with the production of the Sporotrichum conidial phase. Colonies have a raised button in the center with radial wrinkling of the agar. A clear exudate is produced in droplets scattered over the conidial bearing regions. The Graphium stage may be largely suppressed in which case the colonies remain greyish. In some isolates, the Graphium stage is produced abundantly with coalescing of the mucous heads to give a black, gelatinous appearance over much of the colony. Perithecia are produced in abundance in the aerial mycelium and on the agar frequently round the perimeter in older colonies.

This species is close to M. guttulatus but differs from it in having a sparingly setose, flask-shaped perithecium. It is also distinct in having ascospores with numerous small oil droplets.

19. MICROASCUS GUTTULATUS sp. nov. (Plate 2, fig. 7; Plate 10, figs. 1-6; Plate 11, fig. 4)

Perithecia black, carbonaceous, sub-globose to pyriform, 100-250μ in diameter, with papillate ostiole, extremely setose; setae forming a dense mat round the perithecium, usually short, septate, pigmented, smooth; asci ovoid to clavate, sometimes with a well marked foot, 18-26 by 12-18μ, walls remaining till maturity of the ascospores, breaking down to free the ascospores in the perithecial cavity; ascospores plano-convex to concavo-convex, 8.5-10 by 4.5-5.5μ, single-celled, red-brown in color, usually containing a few large oil droplets and several smaller oil droplets. Extruded at maturity as a ball at the mouth of the perithecium or as a long dark-brown cirrhus in older cultures.

Conidial stages Sporotrichum and Graphium; both conidial phases produced abundantly on P.D.A.; Sporotrichum stage arising first with the production of numerous conidiophores from the vegetative hyphae and from aerial strands; simple, hyaline, tapering, up to 30μ long, bearing a number of conidia at the apical end, conidia borne singly on spicules, youngest at the tip, readily displaced, hyaline, variable in

shape from pyriform to long-cylindric or wedge-shaped, tapered sharply at the basal end to a narrow truncate connective, rounded at the apical end, measuring 5-10 by 2-4 μ.

Graphium stage soon evident; vegetative hyphae grow at right angles to the substrate and anastomose and corticate to form coremia; coremia dark-brown colored, up to 1 mm. high, produced singly or in clusters, branching profusely at the top to form hyaline conidial bearing hyphae; conidia similar to the Sporotrichum type but more uniform in shape and released in a mucous to form a large gelatinous head; head at first hyaline, becoming violaceous and finally blackish at maturity; heads frequently coalescing to form large gloeoid masses several millimeters in diameter; conidia similar in shape and size to the Sporotrichum type but averaging slightly larger and more consistently long-cylindric in shape with sometimes an indentation near the center to form a waist.

From: deer dung, Ontario; moose dung, Wyoming; partridge dung, Germany; a contaminated petri-plate, West Virginia.

On P.D.A. the colonies reach a diameter of 6-8 cm. in four weeks. Colonies are white at first turning pale greyish with the production of the Sporotrichum stage and then blackish in patches with the formation of the Graphium coremia in clumps. Growth is irregularly zonate. Perithecia are pro-

duced abundantly at first in the aerial hyphae later in and on the agar especially to the outside of the colonies in older cultures. Pure white cottony overgrowths of Sporotrichum bearing hyphae are sometimes found in the center of the colonies.

A number of cultures of this species have been examined from widely different substrates and locations and the colonies are fairly consistent in growth rate and appearance.

This species shows a close resemblance to M. sordidus in conidial and cultural characters; it differs in having an extremely setose papillate perithecium and distinctive ascospores.

20. MICROASCUS SETIFER Schmidt. Diss. Breslau, Germany. W. C. Korn. 1912. (Plate 2, fig. 6; Plate 11, fig. 1)

Syn. Petriella setifera (Schm.)Curzi. Boll. Staz. Pat. veg. Roma 11:380-423. 1931.

Perithecia membranous, spherical, pale-brown to dark-brown colored, small, 75-125μ in diameter, with short neck, covered with scattered hairs; neck with tuft of ostiolar setae; setae simple, rigid, septate, up to 75μ long, smooth, hyaline to lightly pigmented; asci ovoid to clavate, sometimes with a well marked foot, 21-25 by 12-15μ, evanescent; ascospores symmetrically convex, pointed at the ends, sometimes faintly papillate, walls thinner at the ends to form apical germ-pores, red-brown in color, containing numerous oil droplets.

Conidial stage Sporotrichum; conidiophores arising from the strongly funiculose vegetative hyphae, simple, hyaline, bearing numerous conidia on short spicules near the apical end; conidia tend to unite to form loose balls; conidiophores tapering, usually between 10-30μ long; conidia long cylindrical, wedge-shaped or pyriform, hyaline, tapering sharply to a narrow truncate base 7-14 by 3-4μ. This represents the first recording of the conidial stage of this species.

A Graphium conidial stage has been observed in one culture of this species. Whether this phase was contaminant or a true part of the M. setifer cycle is not known. One might expect it, on the basis of comparison with other species, to possess a Graphium form.

From: horse dung, Germany; oak tree, West Virginia.

Growth of this species is very rapid on P.D.A. covering the diameter of the plate in three weeks at room temperature. Vegetative growth is strongly funiculose, funicles being orientated in a radial direction. Sporotrichum stage produced in abundance in the aerial strands and over the surface of the colonies. Colonies greyish-white at first becoming olivaceous in the sub-surface areas due to pigmentation of the vegetative hyphae. Perithecia are produced abundantly in the aerial hyphae and on the surface of the agar.

M. setifer is distinguished from all other species by

its membranous perithecium with its tuft of ostiolar setae. Its ascospores are distinct in being asymmetrically convex with well marked germ pores.

21. MICROASCUS LINDFORSII comb. nov. (Plate 4, fig. 3)

Syn. Petriella lindforsii Curzi. Boll. Staz. Pat. veg. Roma 11:380-423. 1931.

Chaetomium boulangeri Lindfors. Svensk. Botan. Tidskrift 14: 267-276. 1920.

Perithecia blackish brown, about 350μ broad by 250μ high, mostly between 250 by 175μ solitary, covered with smooth hairs; hairs 50-100μ long, septate, lightly pigmented; crowded round the ostiolar portion; asci oval to pyriform, 18-22 by 11-15μ; ascospores elliptical to fusiform, not apiculate, hyaline when young becoming red-brown at maturity, measuring 8-10 by 4.5-5.5μ.

Conidial stage Graphium; coremia produced abundantly, singly or in clusters, 250-350μ high by 20μ broad; stalk dark-brown to black, becoming hyaline at the tip which becomes much-branched to form the conidial bearing head; conidia hyaline, cylindrical oblong with a papillate appendage at the proximal end, 8-14 by 3.5-6μ.

Recorded only once from the soil in Sweden.

Lindfors also described a creeping, floccose, conidial stage which he apparently regards as merely a phase of the more obvious Graphium stage. This phase would appear to correspond with the Sporotrichum stage of other closely

related species. Lindfors regarded his species as being identical with that described by Boulanger (4). Curzi, however, would regard the two species as being distinct. From a study of the available literature, Curzi seems correct in this and the two species appear distinct both in perithecial and ascosporic characters.

22. MICROASCUS BOULANGERI comb. nov. (Plate 4, figs. 1,2,4)

Syn. Petriella boulangeri Curzi. Boll. Staz. Pat. veg. Roma 11:380-423. 1931.

Chaetomium cuniculorum Boul. nec non Fuck. Rev. Gen. Bot. 7:97-102,166-171. 1895.

Perithecia large, 400-500μ in diameter, black, carbonaceous, spherical base with neck as long as the diameter of the perithecium, covered with flexuous hairs; hairs septate, pigmented dark-brown, lacking incrustations or other special characters, 100-240μ long; asci globose, 24-30 by 18-26μ; ascospores ellipsoid, 9 by 5μ, rounded at both ends, brownish in color, extruded at maturity in the form of a yellowish cirrhus.

Conidial stages belonging to the form genera Sporotrichum and Graphium; vegetative hyphae hyaline, bearing Sporotrichum type conidiophores along their length; conidiophores simple, 30-50μ long, tapering towards the apex, bearing as many as twelve conidia at the distal end; conidia borne singly on short spicules, readily detached, hyaline, pyriform, 7-8 by 4-5μ. Graphium arising from Sporotrichum bearing filaments

after continuous culture; hyphae aggregate to form long, dark-brown coremial; coremial hyphae branch at the apex to produce hyaline conidial bearing branches in a short head; conidia long and narrow produced in mucous forming a transparent ball at the top of the dark stalk.

This species is distinct from M. lindforsii in having a long-necked perithecium and ellipsoid ascospores.

Excluded Species

Microascus lunasporus Jones. Mycologia 28:503-509. 1936.

> On Sabauraud's medium forming a smooth whitish colony, becoming greyish and mealy as conidia develop, then black with the formation of ascocarps, becoming wrinkled and raised above the surface of the agar; mycelium of branched septate hyphae 2-3μ in diameter; no growth on dextrose-tartaric acid media. Conidia produced directly on the mycelium, or on simple or branched conidiophores with sterigmata 5-12μ long; conidia oval to lemon shape, with a collar at the base, 2-4 by 4-7μ. Perithecia developing abundantly on Sabauraud's medium and in Knop's solution, 175-300 in diameter, beaked and with a papillate ostiole, the wall consisting of an outer layer 5 to 8 cells thick, with heavily carbonized walls, and an inner layer of thin-walled colorless cells; asci oval, 7-12 by 7-14μ. Irregularly distributed, eight spored, deliquescing at an early stage; spores lunate, 4-7 by 8-14μ, smooth, extruded in light reddish-brown cirrhi 30-50μ in diameter and reaching a length of one mm.
>
> Type culture isolated from an infection on a human hand. Slides from sub-cultures deposited at the New York Botanical Garden.

The ascospore measurements as given by Jones (20, are apparently in error. Measurements of the ascospores on

the type slides show them to be 2.5-3.5 by 4.5-6.5μ. This would bring the species into the range of M. cinereus to which it appears similar in many respects. Unfortunately there is not enough material on the type slides to come to a definite conclusion regarding this and the species must be considered doubtful. An isolate received from Peoria (Table 1) as M. lunasporus failed to produce ascospores in culture and its vegetative growth was atypical. This isolate was of little value in establishing the possible validity of Jones' species.

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PLATES

Plate 1

Ascospores of various species of *Microascus*

fig. 1. *M. lunatus*

fig. 2. *M. variabilis*

fig. 3. *M. doguetii*

fig. 4. *M. cirrosus*

fig. 5. *Microascus* sp. Orr 4

fig. 6. *M. manginii*

fig. 7. *M. trigonosporus* var. *macrosporus*

fig. 8. *M. trigonosporus*

fig. 9. *Microascus* sp. Orr 12

Plate 2

Ascospores of species of *Microascus*

fig. 1. *M. cinereus*

fig. 2. *M. intermedius*

fig. 3. *M. nidicola*

fig. 4. *M. schumacheri*

fig. 5. *M. stysanophorus*

fig. 6. *M. setifer*

fig. 7. *M. guttulatus*

fig. 8. *M. sordidus*

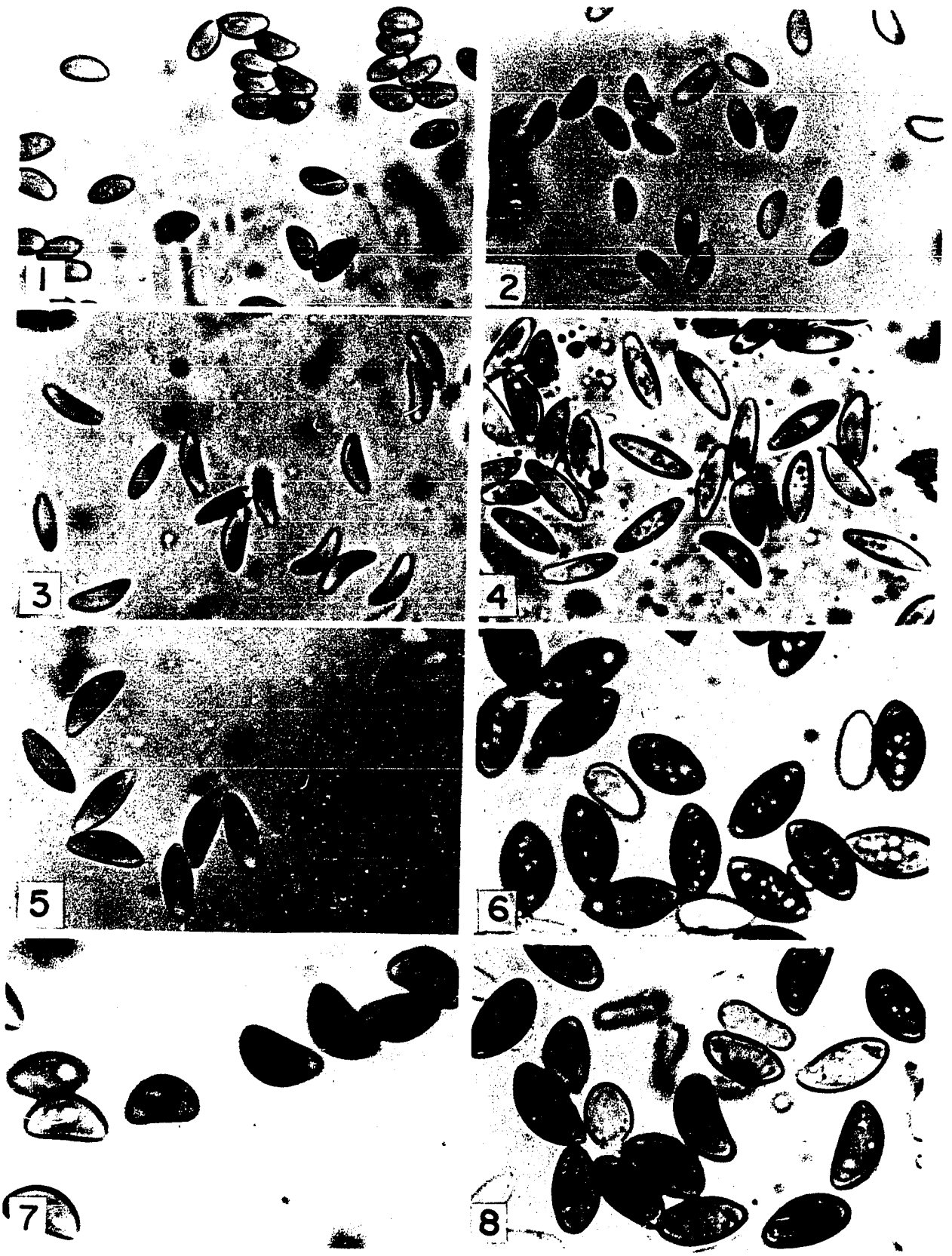
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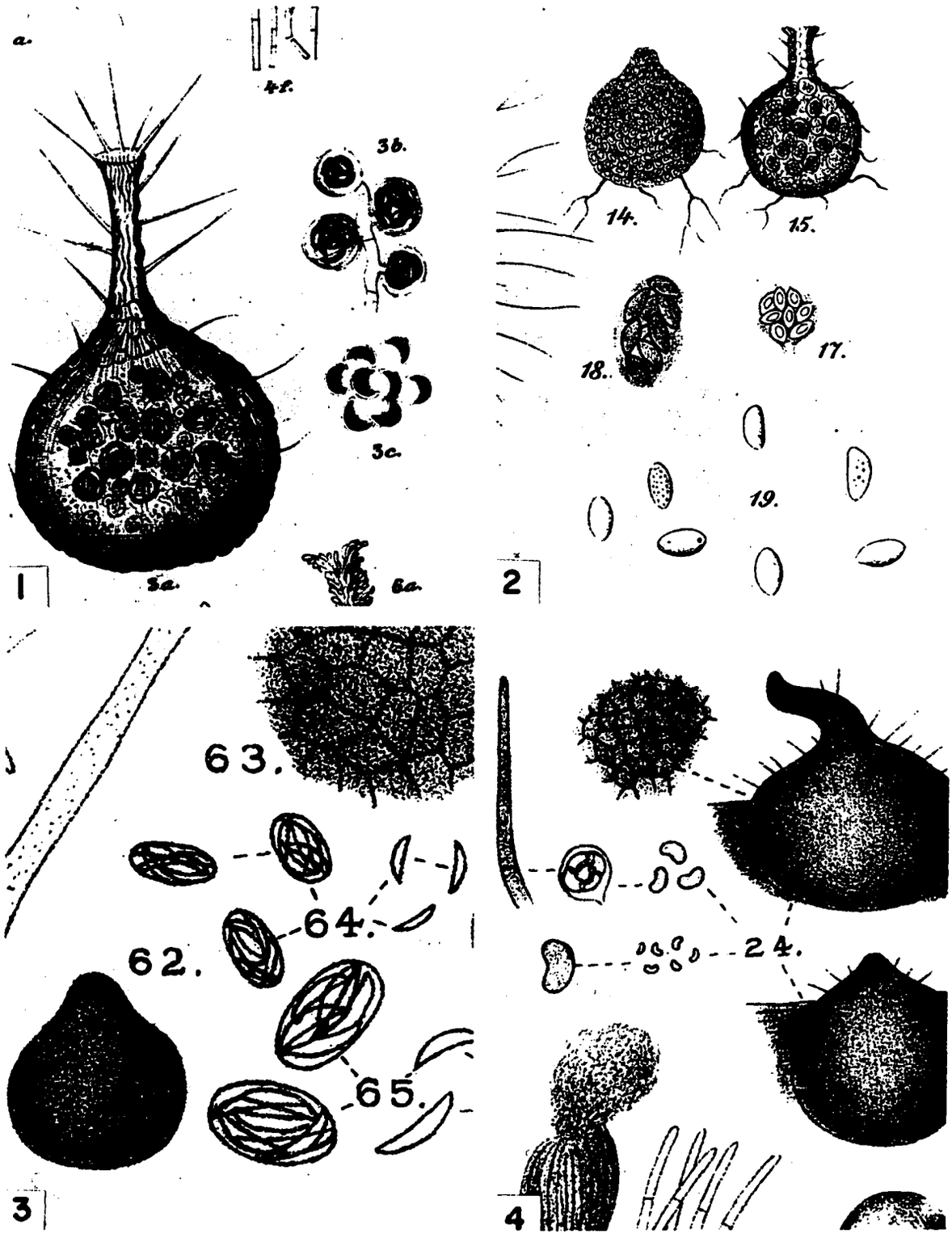
Plate 3

fig. 1. Perithecium(3a), asci(3b), and ascospores(3c) of *M. longirostris* (after Zukal)

fig. 2. Perithecia(14,15), asci(17,18), and ascospores(19), *M. sordidus* (after Zukal)

fig. 3. Perithecium(62), asci(64,65), and ascospores(64,65) of *M. nidicola* (after Massee and Salmon)

fig. 4. Perithecia, ascus, and ascospores of *M. variabilis* (after Massee and Salmon)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24.
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Plate 4

fig. 1. *M. boulangeri*; *Graphium* stage(22') and perithecium(23) of *Chaetomium cuniculorum* Boul. nec non Fuck (after Boulanger)

fig. 2. *M. boulangeri*; *Sporotrichum* stage of *Chaetomium cuniculorum* Boul. nec non Fuck (after Boulanger)

fig. 3. *M. lindforsii*; asci(b), ascospores(b), conidiophores(a), and condia of *Chaetomium boulangeri* (after Lindfors)

fig. 4. *M. boulangeri*; ascus and ascospores of of *Chaetomium cuniculorum* Boul. nec non Fuck (after Boulanger)

fig. 5. Asci and ascospores of *M. doguetii* (after Moreau)

fig. 6. Perithecia(e), conidiophores(a,b) and conidia(a,b,c) of *M. doguetii* (after Moreau)

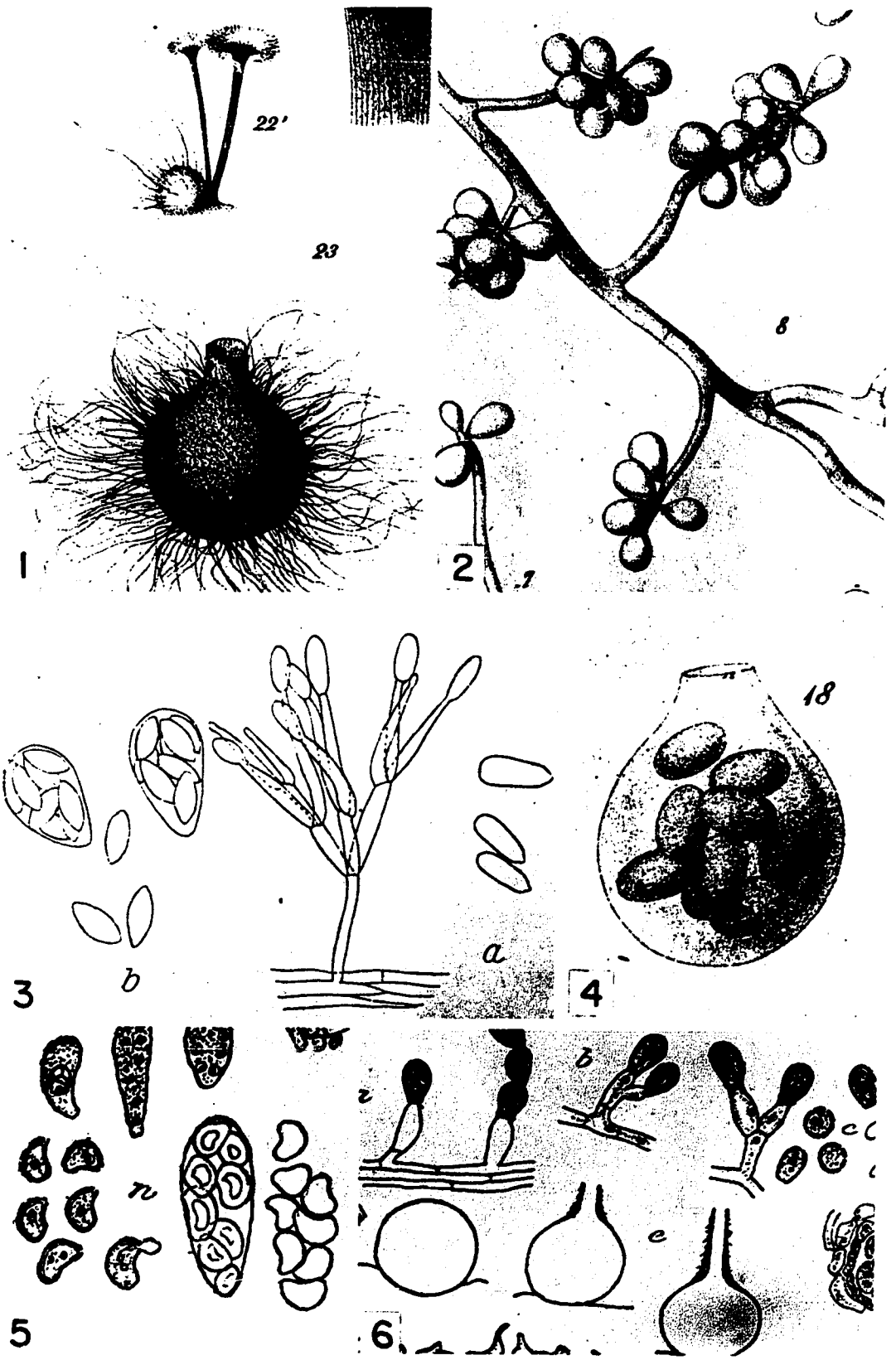
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Plate 5

M. cinereus

fig. 1. Conidiophores

fig. 2. Conidia

fig. 3. Ascospores

fig. 4. Perithecium

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2

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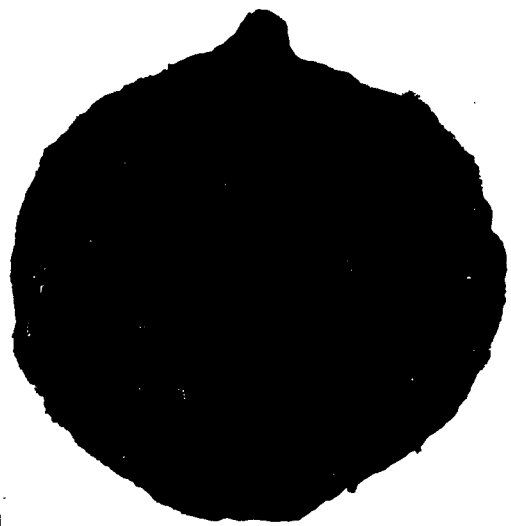

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Plate 6

M. cirrosus

fig. 1. Conidiophores

fig. 2. Hyphal 'rope'

fig. 3. Perithecium

fig. 4. Conidia

fig. 5. Ascospores

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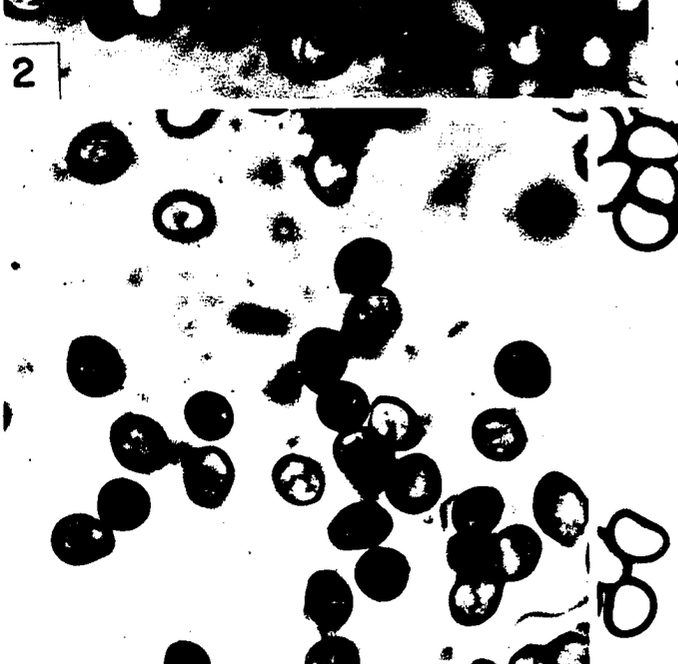

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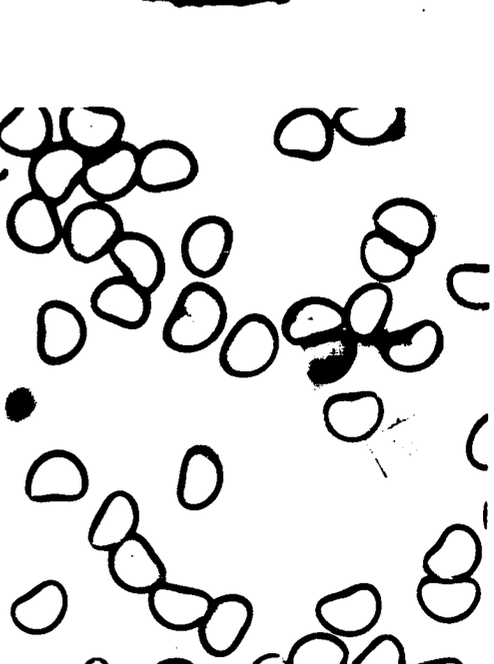

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Plate 7

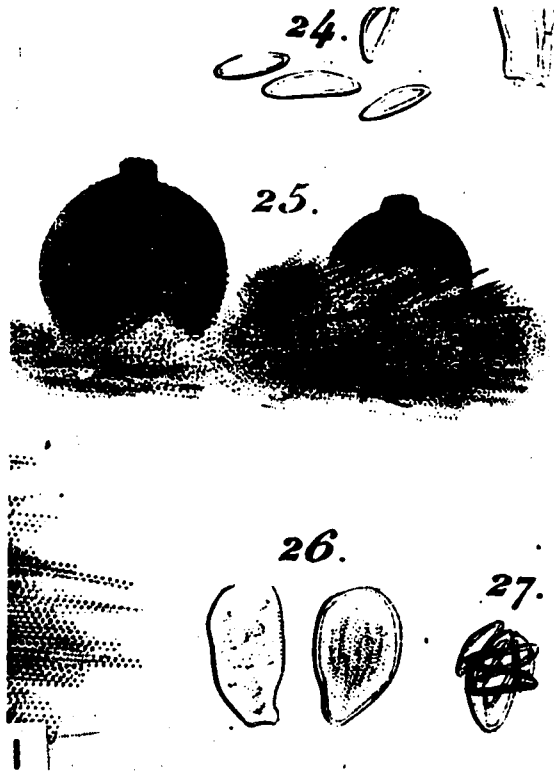
M. schumacheri

fig. 1. Perithecium(25), asci(26), and ascospores(24,27) of Sphaerella schumacheri (after Hansen)

fig. 2. Perihecia

fig. 3. Asci

fig. 4. Ascospores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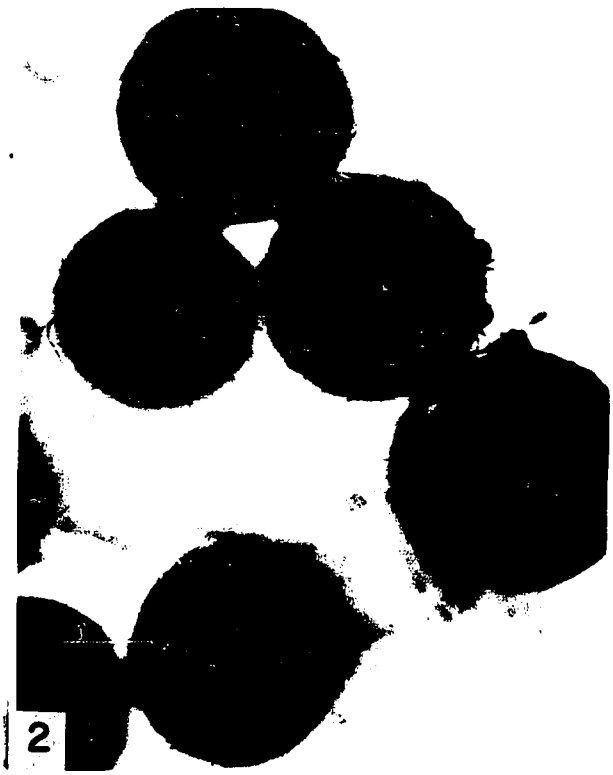
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Plate 8

M. trigonosporus

fig. 1. Perithecium

fig. 2. Ascospores

fig. 3. Conidiophores

fig. 4. Hyphal 'ropes'

fig. 5. Conidia

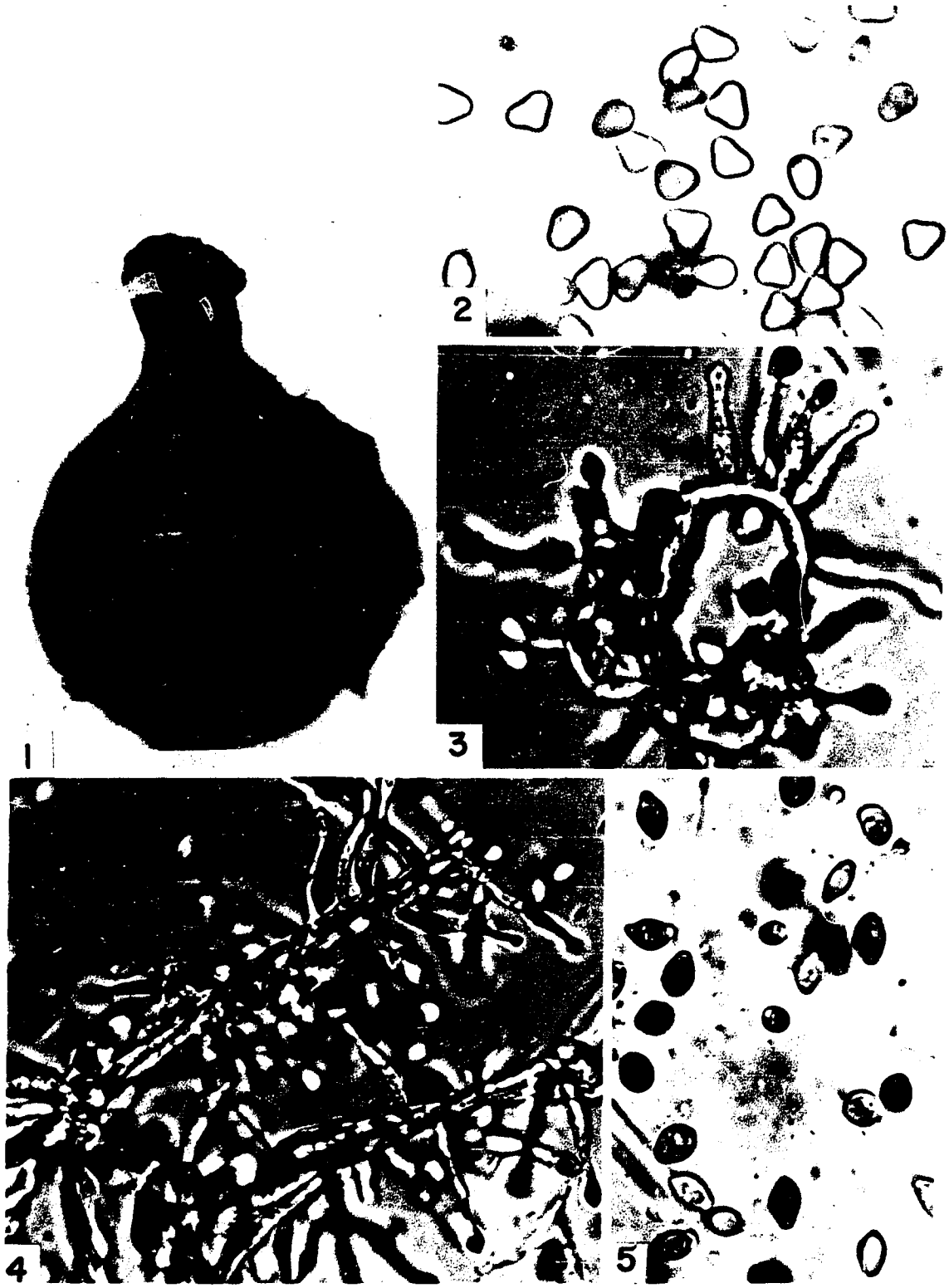
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Plate 9

M. variabilis

fig. 1. Perithecium

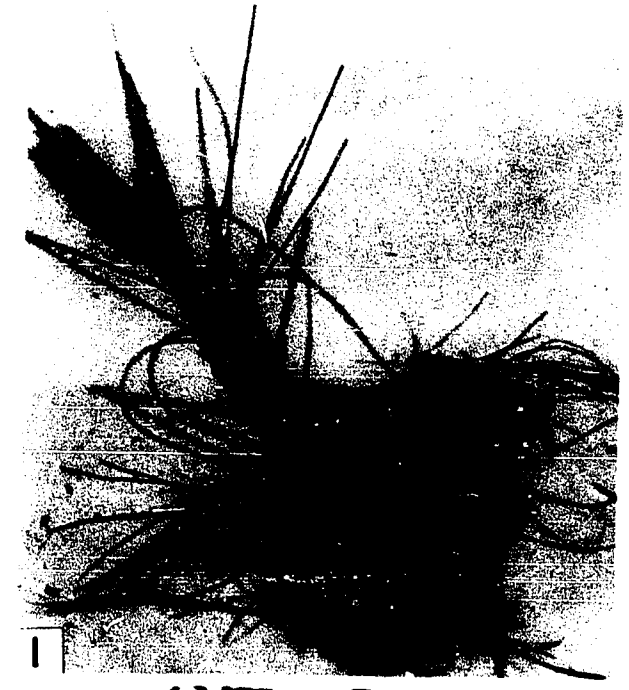
fig. 2. Higher magnification showing ostiolar hairs and remnants of cirrhus

fig. 3. Ascospores

fig. 4. Side view of agar slope in test-tube showing normal perithecia on the surface of the slope and abnormal extension of the neck in sub-surface perithecia

fig. 5. Conidiophores and conidia

fig. 6. Conidiophores and conidia older culture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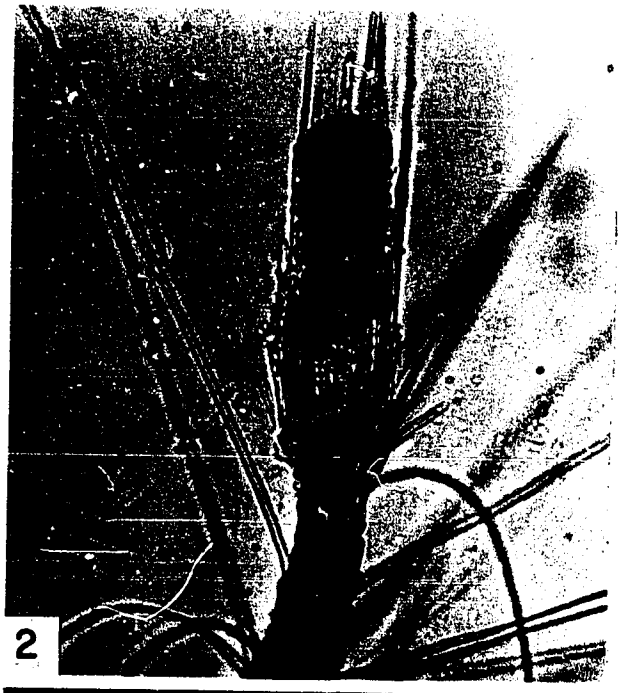
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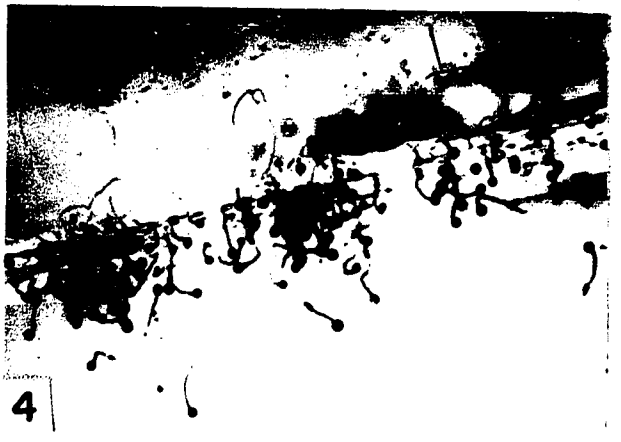
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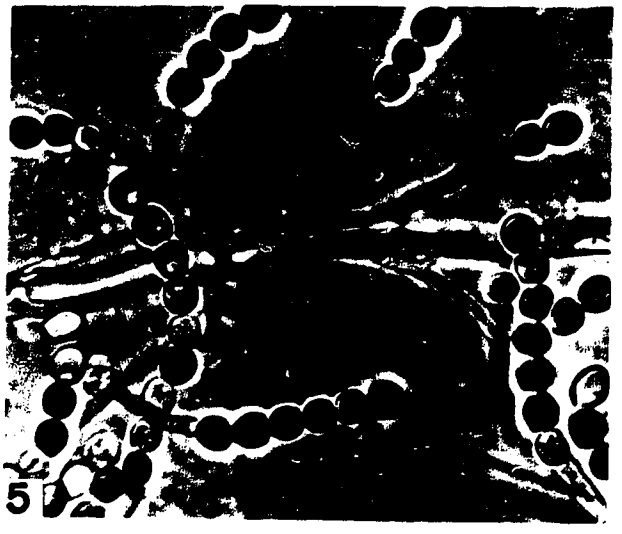
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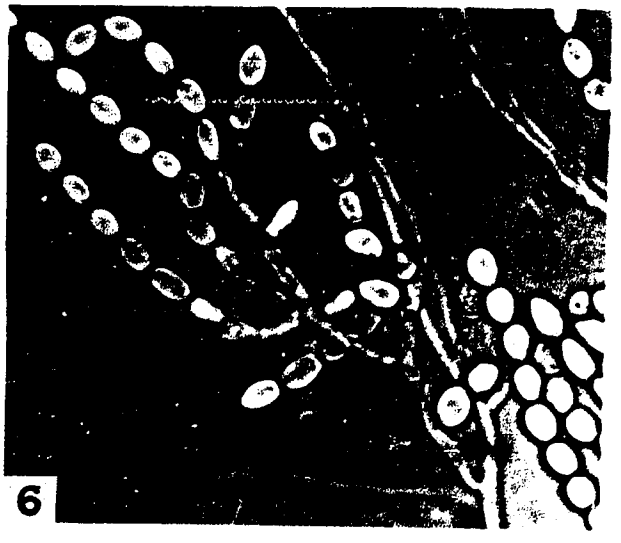
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Plate 10

M. guttulatus

fig. 1. Synnema and sporiferous head of Graphium stage

fig. 2. Conidia, Graphium stage

fig. 3. Ascospores

fig. 4. Sporotrichum conidial stage

fig. 5. Ascus with well developed foot

fig. 6. Asci containing mature ascospores

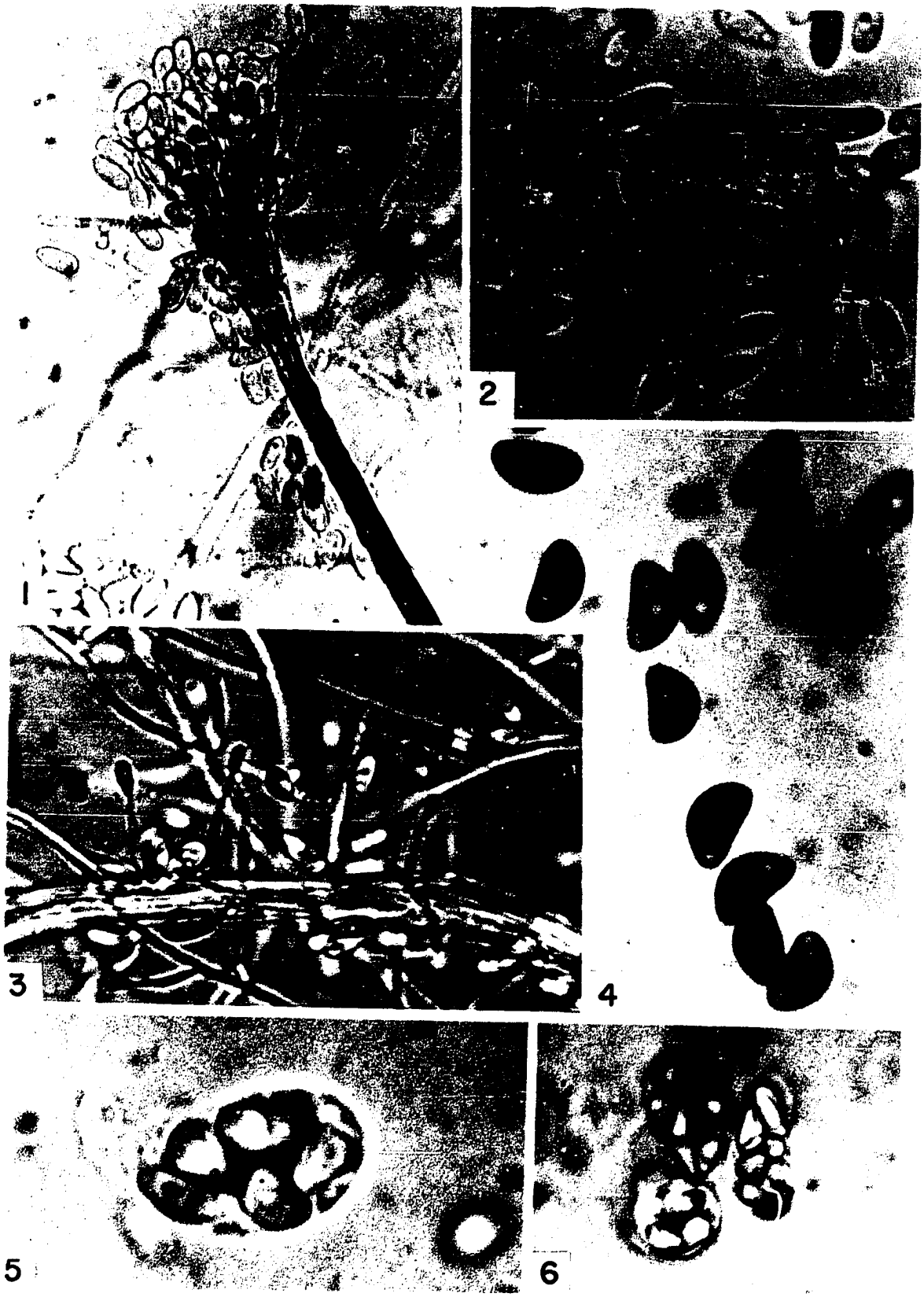
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Plate 11

Perithecia of various species of *Microascus*

fig. 1. *M. setifer* showing ostiolar tuft of setae

fig. 2. *Microascus* Orr 4

fig. 3. *M. sordidus*

fig. 4. *M. guttulatus*; papillate perithecium with remnant of cirrhus; perithecium is extremely setose

fig. 5. *M. intermedius*

fig. 6. *M. manginii*

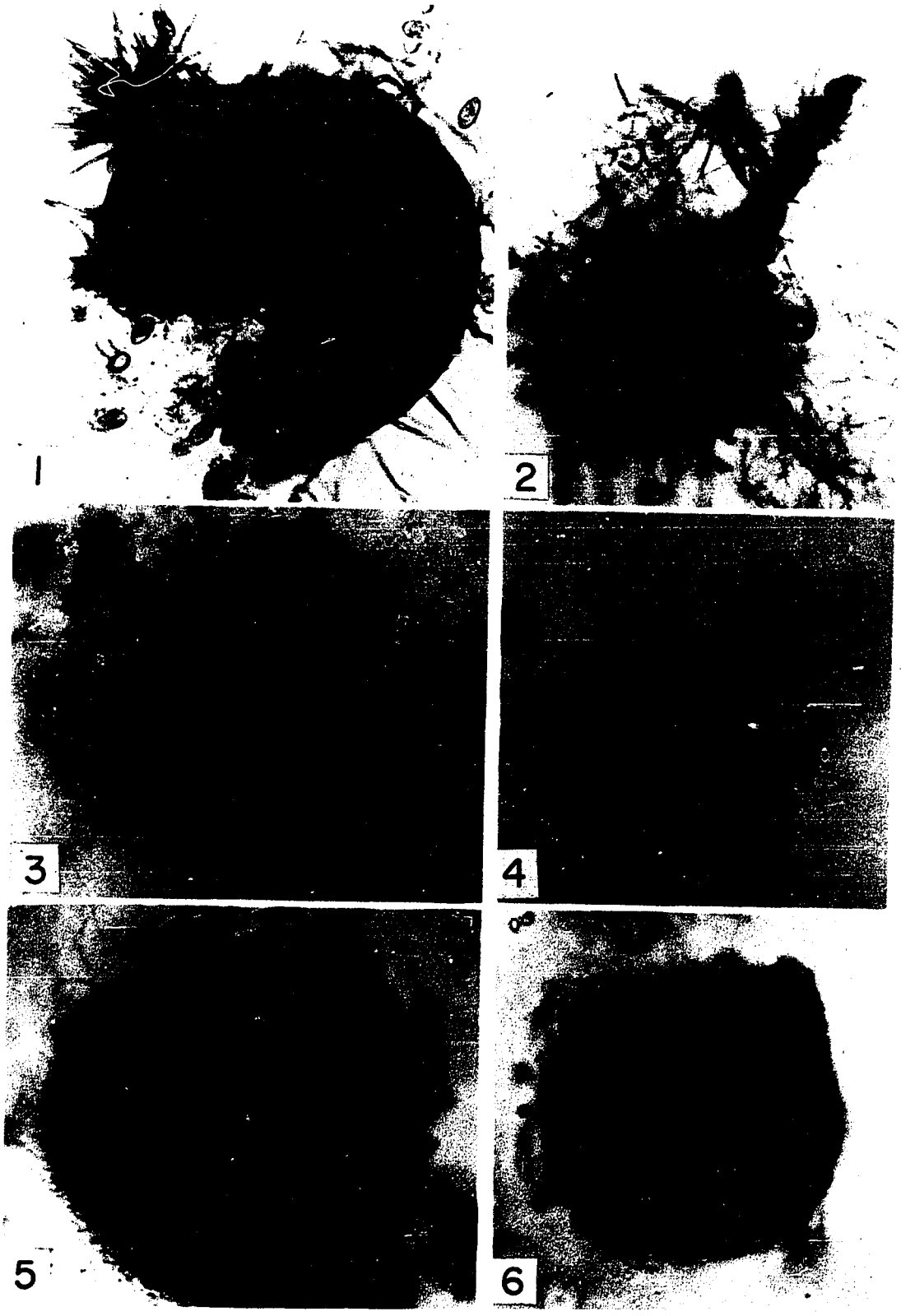
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Plate 12

Four week old cultures of various species of *Microascus*

fig. 1. *M. trigonosporus*

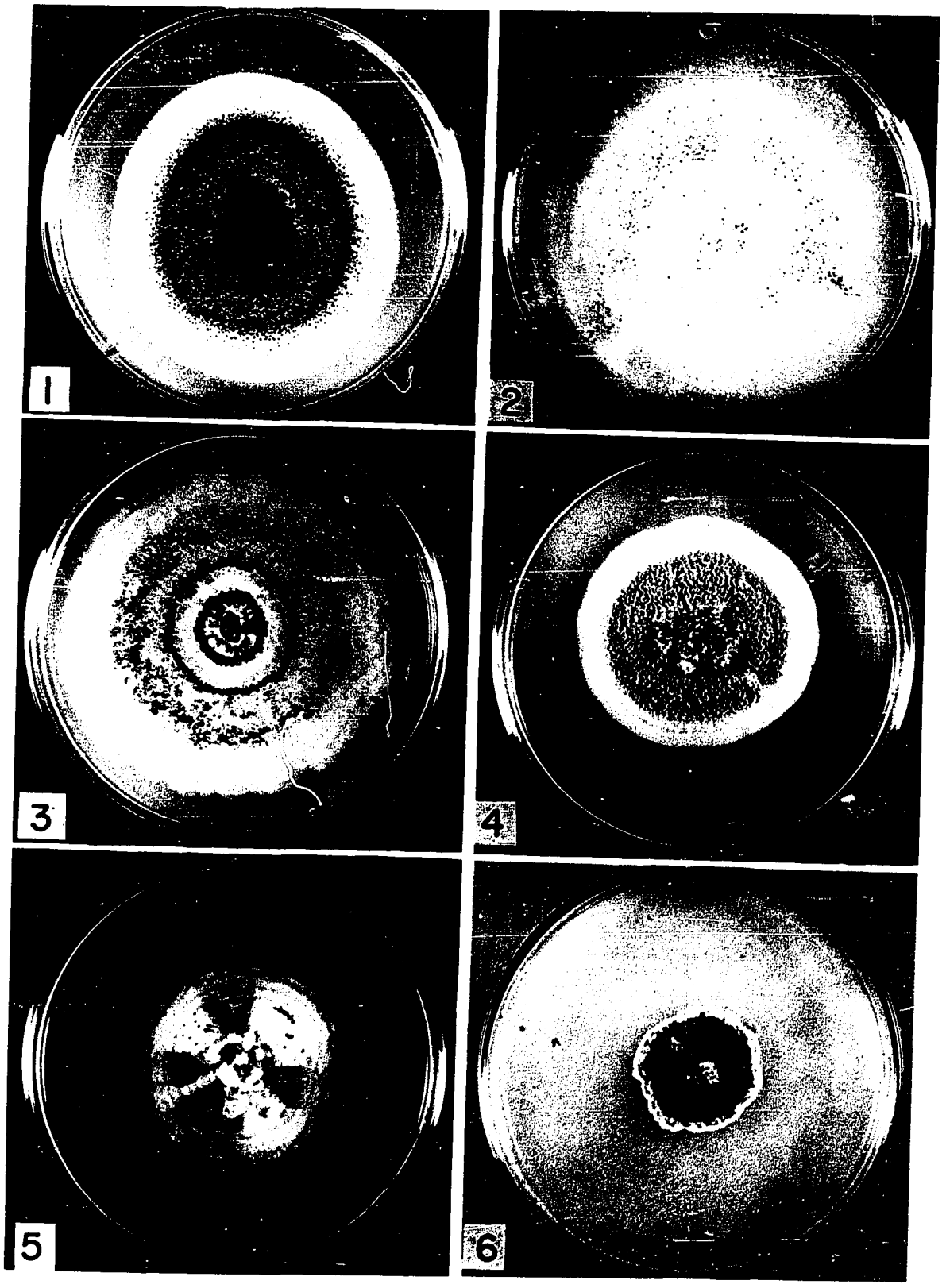
fig. 2. *M. lunatus*

fig. 3. *M. manginii*

fig. 4. *Microascus* Orr 4

fig. 5. *M. variabilis*

fig. 6. *M. nidicola*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